ENGINEERING NEWS-RECORD

DEC 23 1940

Starting second stage of cut for six-track depressed line through Winnetka, Illinois.

DECEMBER 19
1940

Hollow Precast Beams
Earthquake Design
Concrete In Seawater
Asphalt Conference

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CONSTRUCTION TRENDS

Notes on significant movements in the construction industry

Billions for Defense

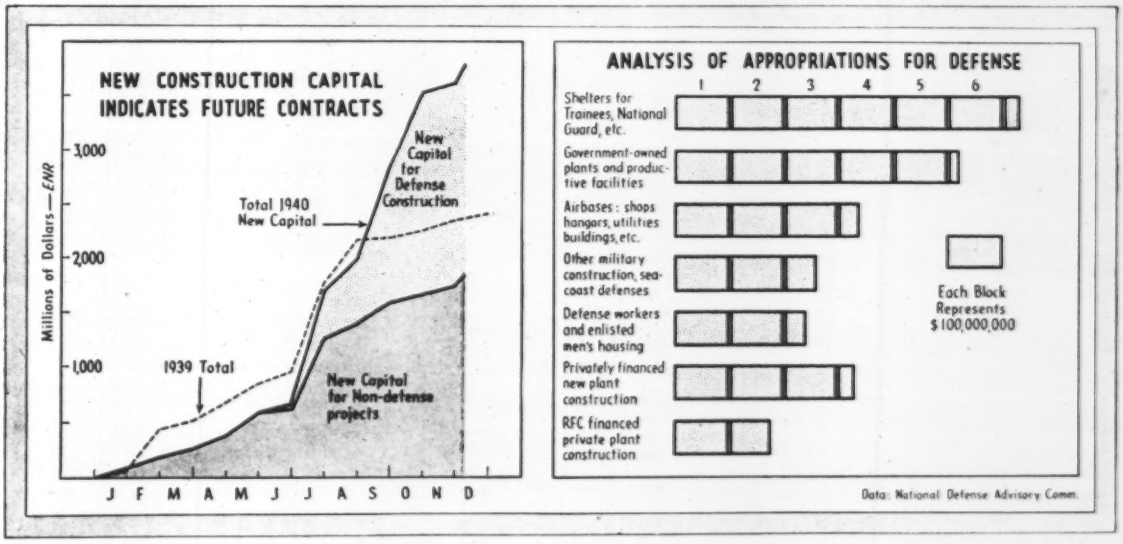
MORE NEW PRODUCTIVE capital has been made available to the construction industry in 1940 than in any year in the preceding decade. The source of the $3,900,000,000 in new construction capital, however, has shifted considerably from 1930 when private investment furnished the bulk of the new financing.

At the present time national defense construction is the primary factor behind this huge construction outlay, and federal funds, therefore, are much more evident than a decade ago. Federal appropriations make up 59 per cent of this year's total, and are 102 per cent higher than in 1939.

Non-federal construction capital, though it does not approach the 1930 volume, increases 27 per cent above a year ago as a result of higher totals in corporate security issues, state and municipal bonds, and private borrowing from the Reconstruction Finance Corporation. Corporate issues, $386,500,000, are up 81 per cent; state and municipal bond sales, $571,000,000, are 5 per cent higher; and RFC loans to private industry for construction, practically non-existent last year, reach $193,000,000. USHA loans, $218,700,000, remain approximately the same as a year ago.

The defense construction program draws funds from the non-federal new capital field as well as from federal appropriations. The National Defense Advisory Commission states that approximately $330,000,000 in defense plant expansion is being carried on by private financing or treasury funds, with a possible increase to $500,000,000 in 1941; and $175,000,000 in private plant expansion is being financed by the RFC.

Of the $2,000,000,000 appropriated by the government for defense construction, it is estimated that almost one-half of this work is under way, and the balance will be carried over into 1941. The federal program, as far as current funds are concerned, will require the building of shelters for trainees, National Guard, Regular Army, and naval personnel at a total cost of $631,000,000; government-owned manufacturing facilities for airplane, engine, armor, tank, ammunition and loading plants, and shipyards and shipways, $520,000,000; airbases, $337,000,000; seacoast defenses and military and naval stations other than airbases, $258,000,000; and defense housing for workers and enlisted men's families, $240,000,000.


NEW CONSTRUCTION CAPITAL INDICATES FUTURE CONTRACTS
Millions of Dollars — ENR
3,000
2,000
1,000
New Capital for Defense Construction
Total 1940 New Capital
1939 Total
New Capital for Non-defense projects
J F M A M J J A S O N D
ANALYSIS OF APPROPRIATIONS FOR DEFENSE
1 2 3 4 5 6
Shelters for Trainees, National Guard, etc.
Government-owned plants and productive facilities
Airbases: shops hangars, utilities buildings, etc.
Other military construction, seacoast defenses
Defense workers and enlisted men's housing
Privately financed new plant construction
RFC financed private plant construction
Each Block Represents $100,000,000
Data: National Defense Advisory Comm.

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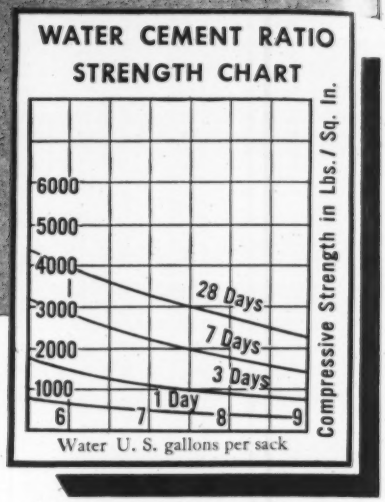
AND YOU GET— *Better* CONCRETE



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F. E. SCHMITT *and* WALDO G. BOWMAN, *Editors* • ALBERT E. PAXTON, *Manager*

Vol. 125 DECEMBER 19, 1940 No. 25

THIS WEEK

• One of the largest grade separations in the country has recently been completed through the residential suburb of Winnetka, north of Chicago. High speed train service had to be maintained while a three-mile-long cut to accommodate six tracks was made and street cross-overs built. How the excavation work was done in three stages, shifting the operating railway lines from one location to another, is told in an important construction article in this issue.

• Hollow concrete bridge girders have been used with success and much economy in the state of Washington. The latest development proposed in the field is the use of several precast hollow box girders side by side to form the entire bridge superstructure. An article in this issue describes the design and testing of one of these girders, which exhibited great strength despite unusually thin walls.

• One of the outstanding examples of the full use of our natural resources for recreational purposes is the Crab Orchard Lake development in southern Illinois. How treated water and other sanitary control features have been applied to turn an ordinary lake into a safe swimming pool for thousands is described in this issue.

THINGS TO COME

• The divided highway presents a special design problem in handling surface runoff. How is it being solved? In our Jan. 2 issue some of the answers will be given based on first hand observation and studies by News-Record editors during the past twelve months. Representing the first attempt to bring together examples of practice in a new field, the article is a timely one.

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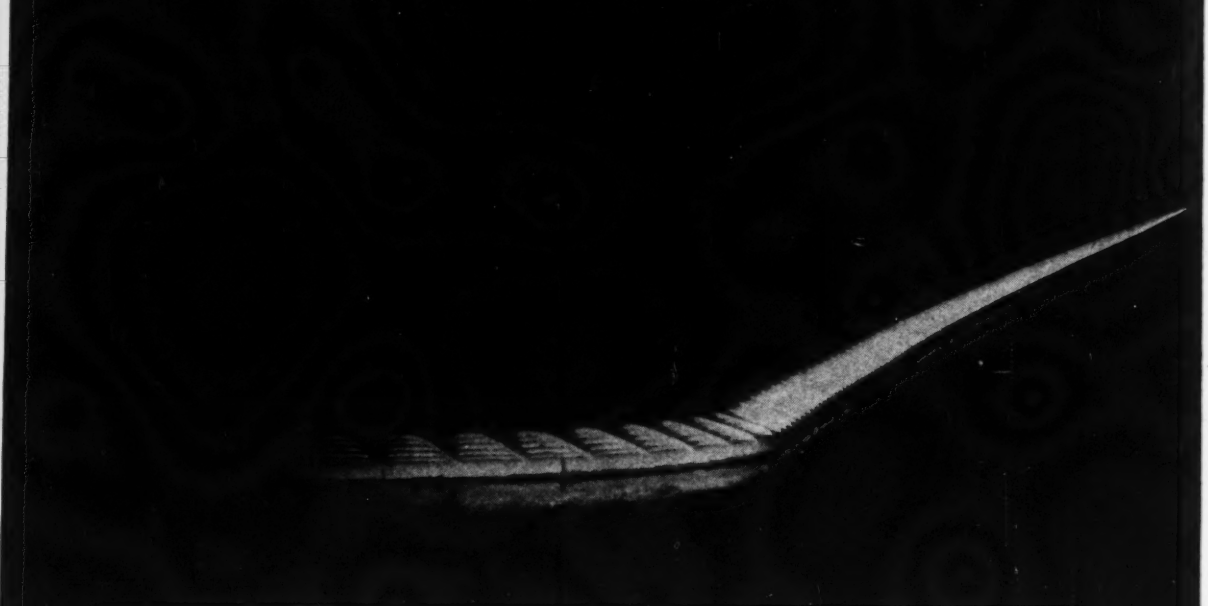
CAR HEADLIGHTS ALONE LIGHT THIS

glowing guide to safety at night!



THIS is White Concrete Reflecting Curb on a rainy, black night when visibility is normally zero. Brilliance of the curb is due entirely to headlight rays which are reflected back to the driver's eyes from scientifically designed sawtooth faces.

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NR-M-15

WHITE CONCRETE REFLECTING CURB

MADE WITH ATLAS WHITE CEMENT

Quartermaster construction reorganized for speed-up

Lieut. Col. Somervell of Corps of Engineers assumes duties as head of division. Decentralized authority first change to get faster action

The construction division of the Quartermaster Corps, loaded with big defense jobs, is being reorganized and decentralized to permit faster and more efficient work. An engineer officer, Lieut. Col. Brehon B. Somervell, has been named to head the division, succeeding Gen. C. D. Hartman, who has retired to the hospital worn out by overwork. Col. Somervell, who has been on leave as WPA administrator in New York City, plans extensive changes in the set-up of the division. He has brought in three other officers from the Corps of Engineers to form the nucleus of his staff—Lieut. Col. W. B. Styer, Lieut. Col. E. H. Leavey, and Capt. C. F. Robinson, as executive officer, chief engineer, and control officer, respectively

Motive for the change has not been announced. Inevitably, the move is being connected with the admission last week that cantonment construction is somewhat behind schedule. Of forty national guard cantonments, 22 are five weeks or less behind, 3 are two to two-and-a-half months behind, and 15 are on schedule. This doubtless precipitated the situation, but more fundamental, apparently, is the desire to utilize on defense projects the experience and methods of the Corps of Engineers. In normal times the Quartermaster Corps handles a much smaller volume of work than is involved in the Engineers' navigation and flood control projects.

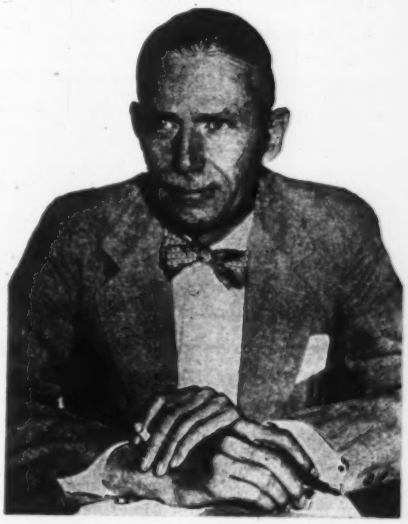
Decentralized authority planned

Most fundamental change which Col. Somervell contemplates is to decentralize authority. In each of the nine Army Corps Areas, a responsible officer will be named to represent the Quartermaster Corps with power to make decisions without referring everything to Washington. This should go far to answer complaints which some contractors have made, that local QMC officers lack authority, are unable or unwilling to make final decisions, and that every move is shrouded in red tape.

In Washington, on the other hand, Colonel Somervell will centralize, consolidating his division into five sections—administration, finance, engineering, construction, and real estate.

Army engineers get airports

Meantime, while Engineer Corps personnel is being drawn on by the Quartermaster Corps, the Engineer Corps itself is getting new defense construction jobs. Army airfield work has been definitely turned over to them with $40,000,000 already appropriated for the program. They will also build the Army garrisons at the new Atlantic island naval bases with Lieut. Col. J. D. Arthur, Jr., division engineer, eastern division, in immediate charge of the work.



Now in charge

Lieut. Col. Brehon B. Somervell (above), former WPA administrator for New York City, has replaced Gen. C. D. Hartman as head of the construction division of the Quartermaster Corps.

Cantonment delays

Cantonment construction delays are attributed by the War Department to a variety of causes, with labor trouble, according to Secretary Stimson accounting for not more than one percent.

The Indiantown Gap, Pa., project was delayed two and a half months by unexpected rock and shale ground conditions. This interfered with pipelines and made it necessary to bring in heavy equipment, which was delayed by necessity of conforming with state laws in moving it over the roads.

Fort Dix, N. J., two months behind, was delayed by existence of a high water table. Moreover a nearby cost-plus defense project drew away much of the labor supply from Fort Dix, a lump-sum project.

Fort Meade, Md., several weeks late, was held up by labor shortage and a strike. Camp Claiborn, La., was delayed a week by heavy rains. Fort Devens, Mass., was held up two weeks by inability to get lumber.

• • •

Engineers depart for work on Atlantic bases

A party of twelve architects and engineers, headed by Ralph Walker and Max H. Foley of the firm of Voorhees, Walker, Foley & Smith, and John P. Hogan and Soren A. Thoresen of the firm of Parsons, Klapp, Brinckerhoff & Douglas, left New York this week for the British West Indies, where they will be engaged on architectural and engineering work for the defense bases in the Trinidad District in accordance with contracts held by their firms with the U. S. Engineers. Other men in the party were: Joe B. Wood, Knox F. Burnett, Edward M. Pratt, of the firm of Parsons, Klapp, Brinckerhoff & Douglas, and Joseph Hautman, Lester Smith, Albert Causey, Paul Wood and James D. Stephens, of the firm of Voorhees, Walker, Foley & Smith. Their organization on this work will be known as Caribbean Architects-Engineers.

The work in the British West Indies is under Col. J. D. Arthur, division engineer of the Eastern Division, whose head-

quarters are in Washington. Major D. A. D. Ogden will be district engineer, with headquarters in Trinidad. His office will direct the work on the islands of Trinidad, St. Lucia and Antigua, and in British Guiana.

Major R. G. Lovett, U. S. Engineer, has left for Jamaica to establish a new district office at Kingston, where he will act as district engineer. A contract for the architectural and design work in this district has been awarded to Moran, Proctor, Freeman & Mueser, engineers, of New York, and Holabird & Root, architects, of Chicago. Their men will leave shortly after Christmas.

For the Bermuda work Shaw, Naess & Murphy are the architects, and Ford, Bacon & Davis and Metcalf & Eddy the engineers. On the Newfoundland work, which is farthest advanced, Fay, Spofford & Thorndike are the engineers and Shreve, Lamb & Harmon the architects.

The above mentioned firms are working only on the Army garrisons at the bases. The Navy's work being separate and under its Bureau of Yards and Docks.

• • •

Survey fund provided for Penn Turnpike extension

Gov. Arthur H. James, of Pennsylvania, has approved an appropriation of between $50,000 and $60,000 from the motor license funds to make a survey of the proposed Harrisburg-Philadelphia extension of the Pennsylvania Turnpike. James said, "The extension from both a civil and military point of view should be expeditiously promoted."

The Turnpike Commission requested the survey, which is to include traffic studies, so that figures could be presented to the federal agencies expected to aid in financing the extension.

• • •

Lincoln Bush, former Lackawanna chief, dies

Lincoln Bush, 80, former chief engineer of the Delaware, Lackawanna & Western R.R., died in East Orange, N. J., Dec. 10. Col. Bush entered the employ of the railroad in 1899 as a bridge engineer and progressed through various positions to that of chief engineer of the system, a post from which he resigned in 1908 to found a consulting engineer's firm in New York. From 1909 until 1925, except for two years in World War service, Bush devoted himself to consulting or contract work, specializing on railroad terminal facilities and electric utilities.

Lincoln Bush is probably best known for his design of the Bush train shed as a substitute for the great arch train sheds of early railroad days. The Bush trainshed consists of flat arches supported along the center of the platforms and spanning two tracks. Locomotive gases are discharged through slots along the track center just above the locomotive stack.

Col. Bush also is credited with development of the sand jack for lowering heavy structures. His war service was on the great port terminals for the Army and industrial warehouses at interior points. He served as president of the American Society of Civil Engineers during 1928, and was elected an honorary member in 1932.

F. E. Schmitt retires from Engineering News-Record

After 38 years' service on the editorial staff of *Engineering News-Record* and its predecessor, *Engineering News*, during the last ten years of which he served as editor, F. E. Schmitt is retiring on Dec. 31, and will serve as staff consultant to the U. S. Bureau of Reclamation. Known to thousands of civil engineers and construction men not only through his writings but by his active and wide-ranging participation in the affairs of the profession, Mr. Schmitt can continue these associations in his new work. At the same time he will maintain his close relationship with *Engineering News-Record* in the capacity of consulting editor.

In commenting on Mr. Schmitt's retirement, James H. McGraw, Jr., president of the McGraw-Hill Publishing Co., stated, "Fred Schmitt has consistently supported the highest ideals of technical journalism, maintaining the traditions for brilliant achievement left by his predecessors of the past 66 years—Stauffer, Wellington, Baker, Goodell, Mehren and Wight. It is gratifying that, despite his new work, his advice and counsel will be available to the staff and to the publishers.

Frederick E. Schmitt

"Joining the staff of *Engineering News* in 1902, after graduation from the University of Wisconsin and a few years in machine construction and structural steel design, Mr. Schmitt's first outstanding assignment was covering the Quebec Bridge collapse in August, 1907. His swift and accurate reporting of the circumstances and cause of the collapse and his subsequent editorials were a definite influence in improving the design of large compression members. Later, his reports of the Florida hurricane damage gave the profession new insight into violent wind action and supported its efforts toward making buildings safer. His painstaking work in introducing Terzaghi's theories on soil mechanics to American engineers marked the beginning of a science that becomes daily more indispensable. His service on technical committees has left its mark on fundamental developments in foundations and in steel and concrete construction. These are but a few of the accomplishments of which his associates are proud and from which the profession has benefited. His new work offers a peculiarly fitting opportunity for him to bring his fine talents to bear on problems of national importance."

In announcing Mr. Schmitt's appointment, Commissioner John C. Page, of the Bureau of Reclamation, pays deserved tribute to his work: "His long and distinguished career as an editor, investigator and consultant on engineering and economic matters, qualifies him admirably to help now in the solution of the many problems connected with placing in operation the many irrigation and supplemental irrigation projects now nearing completion." It will be recalled that, in 1934, Mr. Schmitt, with Mr. John W. Haw of St. Paul, made an investigation and submitted a report on the economics of federal reclamation which pointed to many of the reforms which were incorporated in the Reclamation Project Act of 1939.

Mr. Schmitt will be employed in the Washington office, the Denver office and perhaps other field offices of the Bureau of Reclamation to make special studies and to review plans for project developments. The work will be in both the engineering and economic fields, according to Commissioner Page.

Toronto sewage plant construction delayed

R. C. Harris, commissioner of works for the city of Toronto, has announced that construction of Toronto's sewage disposal plant, estimated to cost $5,600,000, is being delayed because of war conditions. Authorized by the city taxpayers last January, the improvement has been in the process of design since then but has not progressed as fast as anticipated.

U. S. Supreme court broadens federal river control

Court holds that any stream that can be made navigable is under federal control and that such control includes power development, regulation of floods and watershed development

Federal control over rivers was broadened to cover any stream that is now or ever could be made navigable in a decision handed down by the U. S. Supreme Court on Dec. 16 in the 15-yr. old New River case. The case centered around the attempt of the Federal Power Commission to require the Appalachian Electric Power Co. to take out a federal license for its Claytor hydro-electric power project on the New River near Radford, Va., which efforts were resisted in the courts by the power company on the grounds that the river is not navigable and so not within the direct jurisdiction of the commission which finds its authority over water-power projects in the commerce clause of the constitution. The commission held that the river does come within its jurisdiction because it was used for navigation in the past and is capable of being made navigable. This view was sustained by the Supreme Court in a six-to-two decision in which Justice Hughes did not participate. Justice Roberts rendered a strong dissenting opinion in which Justice McReynolds concurred.

The case is long and involved. Construction of the plant in question was first proposed in 1926 and efforts to determine its status were begun then. In June, 1927, the Federal Power Commission made a finding that the New River was not navigable but that operation of power plants on it might adversely affect navigation on the Kanawha. However, in 1932 a new commission reversed that finding and held that the river is navigable within the meaning of the power act. This finding was based on the fact that some of the less steep parts of the river had been used for navigation by small boats in the past and that it was capable of being made navigable by the construction of locks and dams. Two years later, when the power company started construction and refused to apply for a license, the commission sought an injunction in the district court to stop construction. This the district court refused, basing its findings on earlier Supreme Court decisions holding that a river is not navigable under the commerce clause unless it is navigable in fact. This view was upheld in the court of appeals.

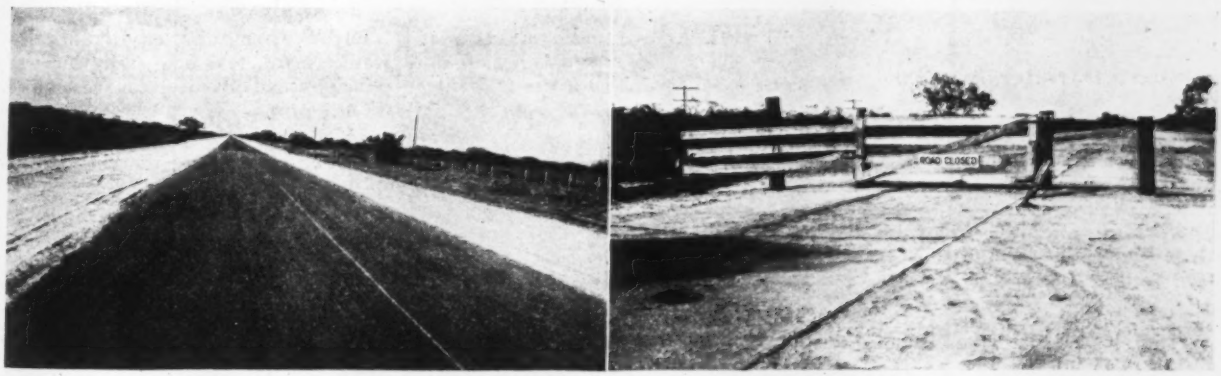
Meanwhile, the plant was completed and now is in operation.

The state of Virginia supported the power company in opposing the extension of federal control over power plants in non-navigable streams as an invasion of states rights. Other states later joined Virginia in its opposition because the theory of the power commission, if upheld, would result in the transfer of most, if not all, present state control over all rivers to the federal government.

Commerce viewed broadly

In reversing the lower courts, Justice Reed, in the majority of opinion said, "In our view, it cannot properly be said that the constitutional power of the United States over its waters is limited to control for navigation. By navigation respondent means no more than operation of boats and improvement of the waterway itself. In truth the authority of the United States is the regulation of commerce on its waters. Navigability, in the sense just stated, is but part of the whole. Flood protection, watershed development, recovery of the cost of improvements through utilization of power are likewise parts of commerce control."

"It is obvious that the uses to which a river may be put vary from carriage of ocean liners to the floating of logs. . . . To appraise the evidence of navigability on natural conditions only of the waterway is erroneous. Its availability for navigation must also be considered. . . . The power of Congress over commerce is not hampered because of the necessity for reasonable improvements to make an interstate waterway available for traffic."



King Ranch road in Texas opened Dec. 17

On Dec. 17 the first main state highway through the famous King Ranch in Kenedy County, Texas, was opened with elaborate ceremonies by the Texas State Highway Department. Ever since through highways were developed by the state of Texas owners of King Ranch have barred a route across their 1,800,000-acre holding in the southern part of the state, forcing all traffic between Corpus Christi and Brownsville to make a 46-mi. detour around the ranch to the west. Since the entire Kenedy County was owned by the King-Kleberg-Kenedy families, legal access across the ranch was held up by a state law requiring the counties to furnish all right-of-way for state routes, as the owners refused to authorize county purchase of necessary right-of-way land. Two years ago the legislature authorized the highway department to purchase a right-of-way for a 55-mile route through Kenedy County, after which the ranch interests donated the necessary land to parallel the Missouri Pacific R. R. between Sarita and Yturria.

Heldenfels Bros., Corpus Christi, have just completed 35-mile of new construction. With completion of 15 miles of reconstruction between Kingsville and Riviera by the M. W. Watson Co., Austin, the cutoff was opened for public use.

All of the route's 55 miles between Sarita and Yturria is cement-stabilized base with a bituminous surface. It is expected that most of the north-south traffic to and from the lower Rio Grande Valley will use the new road, which has been designated as Texas State Route 96.

Right view above shows the barrier that had existed for more than 20 years. At left is a typical view of the new route through the ranch.

Defense roads discussed at asphalt conference in Dallas

Immediate needs reported to be 2,900 miles of access roads to camps and defense projects. Large program of airport construction reported as underway with much more in prospect

Roads for national defense was the theme of the Thirteenth National Asphalt Conference held in Dallas, Texas, Dec. 9-13, as noted briefly in these pages last week. The conference was sponsored by the Asphalt Institute and the Association of Asphalt Paving Technologists, in cooperation with the U. S. Public Roads Administration, the Highway Research Board, and the Texas State Highway Department. Airports also came in for discussion in connection with national defense measures. Research engineers and designers were presented with two full days devoted to technical papers delivered under the auspices of the paving technologists. The full program included subjects of interest to engineers, contractors, and administrating officials.

After an unusually warm welcome to the city and state was given by J. Woodall Rodgers, mayor of Dallas, and Brady Gentry, chairman of the Texas State Highway Commission, the first session got under way with an address by Patrick J. Hurley, former Secretary of War, who pleaded for an adequate network of military highways. He cited the destruction of roads in Texas and Louisiana last summer under army maneuvers as an example of what will happen in case of an emergency unless our roads are up to military requirements.

Access roads most important

The immediate need in military roads, according to a paper prepared by Public Roads Commissioner Thomas H. MacDonald, is adequate access to the 175 camps, training centers and war industry plants already certified to the PRA as being of vital importance. MacDonald stated the requirements at 2,900 miles of access and reservation roads to cost $200,000,000 which must come from new financing. Access roads are more important right now than the strategic military highway network, MacDonald added.

Many angles discussed

The military highway theme was carried further by Capt. W. C. Baker, U. S. Engineers; D. C. Greer, chief engineer, Texas State Highway Department; Bernard E. Gray, chief engineer, Asphalt Institute; Wm. N. Carey, chairman of the Am. Soc. C.E. committee on military road construction and maintenance; C. S. Snead, PRA; W. B. Greene, Barber-Greene Co., and Earle B. Lockridge, chief engineer, Indiana State Highway Department. Capt. Baker outlined the construction standards desired in the strategic network, but pointed out that H-20 bridge loading is far more acceptable than the H-15 loading considered as standard in view of uncertain future developments in army equipment.

Some bottlenecks easily removed

Greer outlined methods of widening existing roads, while Gray presented a thoughtful discussion of how many existing roads can be brought up to military standards by elimination of a few bottlenecks. It is easy, he stated, to provide an additional lane on the right-hand side of steep up-grades for slow-moving trucks that block narrow roads, to open up intersections that cause congestion and to by-pass many existing traffic obstructions.

In speaking of construction and maintenance of roads in military forward areas, Carey outlined equipment and supplies that should be made available to engineering battalions. Snead told how local materials should be selected and used, and Lockridge discussed the placement and storage of essential road materials in the forward areas.

Airports hold attention

Airports received much attention at the meeting. A. B. McMullen, chief, airport section, Civil Aeronautics Authority, outlined the $40,000,000 program for additional airports, and pleaded for an expansion of this program to a system of 4,000 landing fields in the next six years to cost $558,000,000 for construction alone, exclusive of hangars and buildings. He said that in the next two years we will need 2,900 additional hangars and 1,400 other airport buildings (cost $70,000,000) and runways costing $256,000,000 for civil aviation needs alone.

Roy W. Crum, director, Highway Research Board, told how easily highway principles and practices can be applied

One of the few in attendance who understood all of the technical papers was Prevost Hubbard, chemical engineer of the Asphalt Institute.

J. S. Helm (left), president of the Asphalt Institute, chats with Patrick J. Hurley (center), former Secretary of War and keynote speaker at the convention, and J. Woodall Rodgers, Mayor of Dallas. Former-Secretary Hurley spoke on the need of military roads.

to airports, a theme that was continued by E. A. Willis, PRA, in discussing runway subgrades. The Washington National Airport and the Cleveland Municipal Airport were described by Col. Robert S. Thomas, U. S. Engineers, and John Berry, commissioner of airports, Cleveland.

Other technical papers

There were numerous papers presented on the characteristics of asphalts. Also many highway engineers from Texas and other states told about their asphalt highway practices. C. M. Baskin, of Imperial Oil, Canada, discussed tests and experiments being carried on in Canadian roads and airports in using clay as the binder

Bernard Gray, chief engineer of the Asphalt Institute, told of improving existing roads to meet military needs.

for subgrades and bases and asphalt merely as a water-proofing or water-repelling agent.

Prevost Hubbard, chemical engineer of the Asphalt Institute, outlined a laboratory method of determining the correct thickness of asphalt pavements with reference to subgrade support. Maj. Helmer Swenholt, Omaha, Neb. district engineer, U. S. Engineers, told about erosion control and bank stabilization by asphalt methods along sections of the Missouri River.

About 800 were registered at the meeting, and many more were in attendance without registering. Claude L. Makesson, director of research, American Bitumels Co., San Francisco, Calif., and Thomas E. Stanton, research engineer, division of highways, California State Department of Public Works, Sacramento, were elected president and vice-president, respectively, of the Association of Paving Technologists.

Abstracts of many of the papers presented at the conference will be given in a subsequent issue.

Rochester water contaminated through connection with fire protection system

In 17 hours 4,000,000 gal. of contaminated river water was pumped into municipal mains, which serve half of city

Polluted water from a fire protection supply was pumped into the Rochester, N. Y. municipal system on Dec. 11, when a valve cross-connecting the two systems was opened by mistake. In the 17 hours that elapsed before the valve was closed about 4,000,000 gallons of sewage-contaminated water from the Genesee River entered the municipal mains. About half the area of the city was affected, the balance being served by a separate distribution system under private operation.

Fear of an epidemic in this city of 300,000 led to swift action on the part of city and state health authorities. Earl Devendorf, assistant director of the New York division of sanitation, ordered immediate chlorination of the distribution system and brought with him typhoid vaccine to be used in clinics established throughout the city. Three emergency-type chlorinators, supplied by the Wallace and Tiernan Co., were used to sterilize the 500-mi. network of pipes.

Superintendent suspended

The day following the discovery of the open valve, city manager Louis B. Cartwright and Public Works Commissioner William H. Roberts conducted an investigation. This resulted in the immediate suspension of Lewis E. Kohl, superintendent of water, and Ernest G. Jones, a 30-yr. veteran of the water bureau who was in charge of repairs.

The facts brought out in the inquiry so far are these: Work was started on Dec. 11 to repair a 10-in. gate valve which

New Kentucky Bridge tolls total $8,588 first six weeks

Tolls collected up to Nov. 30 on the new highway bridge at Rockport, Ky. over the Green River, which was dedicated and opened Oct. 21, total $8,588. Toll rates for this structure, which was built by the Kentucky State Highway Department at a cost of $530,000, vary from 50c. for passenger automobiles to 85c. for motor trucks and other vehicles over 1½ tons capacity.

The new 1,840-ft. bridge, consisting of six 50-ft. steel girder spans, seven 118-ft. deck steel truss spans, one three-span cantilever truss unit 700 ft. in length, was financed by a PWA grant. H. M. Dodd was PWA resident engineer inspector and Sverdrup & Partel, St. Louis, Mo. were the consulting engineers. Spencer and Ross, Inc., were the substructure contractors; Perry McGlone Construction Co., and Clark, Kearny & Stark were the approach contractors. Lamar Riney and Geo. H. Hailey were resident engineer and district engineer, respectively, for the Kentucky highway department.

was found to be inoperative by an inspection gang who had reported the condition some weeks previous. After the repairs were made, the valve was left open in the mistaken belief that this was the normal operating condition. No one knew at the time, and the water bureau records did not show that this valve formed part of the old cross-connection between the separate fire protection and municipal water mains.

The fire system, which was installed in 1874, is a pumped supply from the Genesee River. It was believed that all cross-connections originally made with the municipal mains had been removed years ago.

First intimation that all was not well came soon after the valve was opened on the afternoon of Dec. 11. The pressure on the fire system pump gage dropped from 95 to 65. Complaints about discolored water reached the city manager in increasing number and at midnight he ordered a check-up by the water department. The cause was not discovered until 8 a.m. when a workman revealed that a valve had been left open.

Bacteriological examinations revealed "gross pollution" of the water. Typhoid organisms have not been isolated and it will require 10 to 14 days before typhoid symptoms, if any, are revealed. Health authorities report that since the pollution occurred hundreds of cases of intestinal disorders are being treated.

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Goods for living as well as defense urged

Representatives of the 40,000 manufacturers affiliated in the National Association of Manufacturers and the National Industrial Council, meeting in their 45th annual convention in New York last week, pledged themselves not only to meet every demand for defense armaments but to keep the goods and services of normal living rolling off the production lines. Making good on this pledge is recognized by construction leaders as meaning much to construction in the period after armament plants now under way are finished. Phillip D. Reed, chairman of the board, General Electric Co., characterized the production of normal goods as one of the best possible obstructions to inflation. "Unless these goods are available in sufficient quantities, to meet the demand," he said, "prices will tend to move upward and will in turn exert inflationary pressures all along the line."

The association also urged that during the defense spending period rigid economy in non-defense expenditures of federal, state and local governments be practiced. It opposed the St. Lawrence waterway and power project, as obstructing the defense program.

JOBS OF THE WEEK

HAMILTON AVE. BRIDGE, Brooklyn, N. Y.

P. T. Cox Construction Co., New York, was low bidder with a bid of $1,190,501 for constructing the Hamilton Ave. Bridge over Gowanus Canal when bids were opened Dec. 10 by the Park Department, New York.

AIRPLANE FACTORY, Bridgeton, Mo.

H. B. Deal & Co., St. Louis, Mo., is building the airplane factory for Curtiss-Wright Corp., Bridgeton, Mo. and New York, N. Y. Cost of construction is estimated at $6,000,000; equipment is expected to cost $10,000,000.

RELOCATION OF RAILROAD TRACKS, Herkimer, N. Y.

New York Central R. R., New York, N. Y., J. W. Pfau, chief engineer, will relocate with its own forces the four main tracks at Main Branch junction in the village of Herkimer. Estimated cost of the work is $1,000,000. The New York State Highway Commission will eliminate the grade crossing in Herkimer.

AMMUNITION DEPOT, Charleston, S. C.

C. M. Guest & Sons, Anderson, S. C., was awarded the contract for constructing an ammunition depot at Red Bank plantation near Charleston. The Navy Department, Washington, is doing the work, which is estimated to cost $1,000,000.

RESIDENTIAL COMMUNITY, Manhasset, N. Y.

Levitt & Sons, Manhasset, will build with its own forces a residential community, including stores, along Northern Blvd. The work is expected to cost $12,000,000 with sixty homes to be ready in the spring.

ESCALATORS, Chicago, Ill.

Otis Elevator Co., Chicago, Ill., was low bidder with a bid of $924,523 for constructing twenty-nine escalators for the State Street and Dearborn Street subway stations. Department of Subways and Superhighways, Chicago, took bids for the work Dec. 5.

TNT AND DNT PLANT ADDITION, Wilmington, Ill.

Stone & Webster Engineering Corp., New York, N. Y., received an increased appropriation of $20,137,000 from the War Department for design and construction of a TNT and DNT plant at Wilmington, Ill. E. I. duPont de Nemours & Co., Wilmington, Del., will operate the plant. Sanderson & Porter, New York, are constructing a $14,000,000 ammunition loading plant on the same site for the War Department.

HOSPITAL, Charleston, S. C.

J. C. Heslep, Columbia, S. C., received the general contract for constructing a hospital on Dorchester Road near Charleston in Charleston County for the War Department. The work is estimated to cost $1,500,000.

DEFENSE HOUSING UNITS, San Diego, Calif.

McNeil Construction Co., and Zoss Construction Co., Los Angeles were awarded a $9,070,000 cost-plus-fixed-fee contract for constructing 3,000 defense housing units on 800-acre site. The project will provide housing for industrial workers employed in the local aircraft industries. Public Buildings Administration, Washington, is doing the work. The contractor's fee is $300,000.

ANTI-AIRCRAFT FIRING CENTER, Wilmington, N. C.

F. N. Thompson, Raleigh, N. C. and J. J. McDevitt Co., Charlotte, N. C., were awarded the War Department's contract for constructing the anti-aircraft firing center, including 1,000 buildings in the Holly Ridge area, near Wilmington. Estimated cost of the work is $9,000,000.

AIRPLANE PLANT, Cincinnati, O.

Frank Messer & Sons, Cincinnati, O., were awarded the general contract for constructing an airplane plant and office building for the Wright Aeronautical Corp., Paterson, N. J. Total estimated cost of the plant is $37,000,000.

SMALL ARMS PLANT, St. Louis, Mo.

War Department awarded the contract for procuring equipment, supervising design and construction of a plant to the Western Cartridge Co., East Alton, Ill. Of the $18,600,000 expenditure, $7,500,000 is expected as necessary for construction.

NEW LOCKS, Panama Canal

Martin Wunderlich Co. and Okes Construction Co., Jefferson City, Mo., were awarded the contract for the rough excavating for the new locks near Gatun Lock, Panama Canal. General Purchasing Agent, Panama Canal, awarded the contract for the work, which is expected to cost $8,517,100.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News Section beginning on page 107.

OBITUARY

H. S. THOMSON, 67, civil engineer who assisted in the construction of the Pennsylvania Station and the Grand Central Terminal in New York City, died in New York City, Dec. 16. He had served as consultant for the Gulf Refining Co. and the Baltimore and Ohio R. R.

CHARLES M. BRELLENTHIN, 72, who was associated with his sons in the highway contracting firm of Brellenthin Truck & Shovel Service, Inc., Elkhorn, Wis., died in St. Croix Falls on Dec. 8.

ALEXANDER M. BELL, 58, past president of the California Sewage Works Association, died at Woodside, Calif., Dec. 10. He was western vice president of Wallace & Tiernan Co., and had been in business at San Francisco for the past 21 years.

ANDREW MEEHAN, 49, president of John Meehan & Sons, contractors of Baltimore, Md., died Dec. 7, in Philadelphia.

MICHAEL J. O'MEARA, 69, retired builder who served as vice president and general manager of the Longacre Construction Co., New York, died in Philadelphia last week.

THURMAN H. MYERS, 50, former resident engineer with the Kentucky State Highway Department and lately chief engineer and geologist of the Carnegie Natural Gas Co., died Dec. 9 at Pittsburgh.

HERMAN W. BERNARD, 76, civil engineer formerly connected with the Carnegie Steel Co., died in Pittsburgh Dec. 9.

OWEN M. FREDERICK, 52, principal civilian engineer in Cleveland for the Great Lakes Division office of the U. S. Engineers, died Dec. 12 in Chicago.

LOUIS W. WALKER, 69, chief draftsman of the Pennsylvania R.R. and employee of that system for 44 years, died at Montclair, N. J. Dec. 15.

GEORGE T. BAKER, 83, for 15 years president of the Iowa State Board of Education and engineering graduate of Cornell University, died in Davenport, Ia. Dec. 13. For six years he was engineer at Davenport for the Rock Island R.R. Later he worked with the Santa Fe line.

W. KENNETH EICHFELD, 36, vice president of William F. Eichfeld & Sons Co., structural steel firm of Milwaukee, died Dec. 9.

ERNEST M. CRAWFORD, 48, civil engineer of Marion, N. C., was fatally injured in an automobile accident near that city Dec. 10.

JOHN N. ROHERTY, 56, manager of North Dakota State Highway Planning Survey, died recently after several months illness.

ERNEST B. BAIN, 71, associated with the water works system of Raleigh, N. C. since 1897, and past president of the North Carolina Section of the American Water Works Association, died in Raleigh, December 9.

L. L. ALLEN, 41, former state highway maintenance engineer for the Minnesota State Highway Department, was killed in an auto accident near Terry, Mont., recently.

JAMES W. SHEARER, 74, railroad builder in Alaska and the state of Washington, died Dec. 7 at Seattle.

SVERRE N. BERGESEN, 55 of Valley Stream, L. I. was killed in an automobile accident Dec. 14. Bergesen was superintendent of the Flushing concrete plant of J. & I. O'Rourke, Inc., New York.

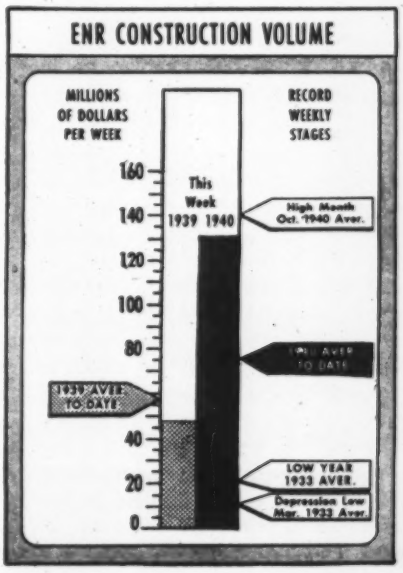
ERNEST MILTON SALTER, 51, resident engineer on the construction of the new airport at St. Catherines, Ontario, died at his home in Toronto Dec. 13. He was a graduate of the University of Toronto with the class of 1911.

CONTRACTS AND CAPITAL

ENGINEERING CONSTRUCTION awards for the week, $131,135,000, reached the fifth highest volume of the year, 175 per cent higher than in the corresponding 1939 week, and 60 per cent above last week. A combination of high totals in the building field, industrial, commercial and public, accounts for 81 per cent of the week's awards, and is responsible for the increased volume.

Private awards are 349 per cent above a year ago and 74 per cent higher than a week ago. Public construction is 136 and 55 per cent higher, respectively, than last year and last week.

The 1940 51-week volume, $3,911,902,000, tops 1939 by 32 per cent, and exceeds all annual totals except the record volume of 1929, $3,950,315,000. Private awards for the current year are 31 per cent over a year ago. Public construction gains 33 per cent over a year ago as a result of the 305 per cent increase in federal awards.



Commercial building and large-scale private housing reached the highest point reported since August 24, 1939; and public buildings are the fourth highest of the current year. In addition to these classes of work, waterworks, sewerage, bridges, earthwork and drainage, and streets and roads top their last week's totals; and industrial buildings are above last year.

New capital for construction purposes for the week totals $5,847,000, a decrease of 15 per cent from the 1939 week. New construction financing for the year to date, $3,883,841,000, tops the period last year by 62 per cent.

CONTRACTS

(Thousands of dollars)

	Week Ending Dec. 21 1939	Dec. 12 1940	Dec. 19 1940
Federal	$8,867	$41,892	$69,864
State & Municipal	30,089	17,259	21,942
Total public	$38,956	$59,151	$91,806
Total private	8,746	22,574	39,329
TOTALS	$47,702	$81,725	$131,135
Cumulative 1940	(51 weeks)		$3,911,902
1939	(51 weeks)		$2,958,128

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1939 51 Wks.	1940 51 Wks.
NON-FEDERAL	$1,266,854	$1,601,880
Corp. Securities	213,803	389,062
State & Mun.	559,640	574,194
R.E.A. loans	89,445	40,000
U.S.H.A. loans	215,811	218,704
R.F.C. loans	—2,277	195,920
Fed. Aid-Hwy.	190,000	184,000
FEDERAL	$1,128,028	$2,281,961
TOTAL CAPITAL	$2,394,882	$3,883,841

FHA MORTGAGES

	Week Ending Dec. 16 1939	Dec. 7 1940	Dec. 14 1940
Selected for appraisal	$18,160	$19,705	$20,203*
Cumulative 1940	(50 weeks)		$1,232,409*
1939	(50 weeks)		$1,097,321

* Subject to revision.

ENR INDEX NUMBERS

		1913	1926
Index Base = 100			
Construction Cost	Dec., '40	249.12	119.75
Building Cost	Dec., '40	208.19	112.54
Volume	Nov., '40	331	145

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

Resonance Effects of Wind

Sir: The failure of the Tacoma Bridge brings to light much mysticism attached to vibration and stability, although these are rather simple matters. Let a force be applied to a body causing a deflection or a deformation, and let the force be suddenly removed; then the body returns to its original position, acquiring a momentum that gives it a secondary displacement, equal and opposite to the original. Suppose, while the secondary displacement is at its height, a force equal in magnitude and direction to the first is applied and quickly removed. Then the inertia plus the second force will create a displacement twice as great as the original. A third force equal in all respects to the other two will produce three times the displacement and so on.

Forces that oppose the secondary movement "damp" the vibration, that is they tend to lessen its amount. With mixed forces, add the effects of those that tend to increase vibration and subtract the effects of those that dampen and of friction.

Wind, the force that destroyed the Tacoma Bridge, is often conceived of as a steady horizontal force; actually, however, it is made up of areas of varying intensities and direction. It is a matter of common knowledge that neither a loose rope nor a tree remains at a constant angle during a storm but sways back and forth.

The floor of the Tacoma Bridge was carried by a cable, the position of the cable depending upon the loads that it carried. Consider now that a gust of wind with an upward pressure acts briefly upon the floor for 100 ft. of its length. The cable above and near this 100 ft. will rise and the rest of the cable will be depressed. If the wind slacks, the reverse movement takes place and the momentum of the cable carries it as far from the normal in the other direction. Suppose just at this point the lifting effect is applied again, we then have a double deflection. This may continue until extensive motions are set up such as those that actually destroyed the bridge. Or again they may come at times which dampen the vibration.

Note that entire synchronism is not necessary; even partial synchronism would be somewhat effective, that is, would result in considerable oscillation. That is, even though the wind did not come at the right time and there was some dampening, the resultant might still cause some oscillation and wave motion.

If the lifting force was different on opposite sides of the bridge it would be expected that the wave motions would be out of step.

Before accepting definitely the results of wind tunnel experiments I would want conclusive proof that a wind tunnel current was the same as the wind that existed Nov. 7 at Tacoma Narrows. Streamlining the girders would reduce the horizontal wind pressure; however, I would prefer to reserve opinion as to what it would do to uplift or suction. The wind was said to have had a velocity of 40 mph. What would have happened if the velocity had been 100 mph?

H. R. THAYER
State College, Pa.

Action of "Karman Vortices"

Sir: The article by N. A. Bowers and Prof. von Kármán's letter (*ENR*, Nov. 21, 1940) have presented a great deal of important and interesting information regarding the vibration and failure of the Tacoma Narrows Bridge. The discussions, however, have mentioned only "aerodynamic instability" as the factor causing the bridge to vibrate in the wind. There is another factor, very possibly important in this case, which does not involve such "instability."

A perfectly round cylinder, supported elastically, can be made to "bounce" in a transverse wind of very moderate velocity. This phenomenon has been studied at great length with regard to electric transmission lines, and is similar to the "singing" of telephone wires in the wind. The writer has constructed a simple model of a 2-in. cylinder mounted on springs. When subjected to a wind of 5 mph the cylinder builds up a vertical "bounce" of 2 in.

This vibration is entirely apart from that of an "aerodynamically unstable" member. As discussed in Mr. Bowers' article, aerodynamic stability of a member may be investigated in wind-tunnel tests, by measuring the relationship between wind direction and the resultant vertical force or lift on the member. However, for a cylindrical member the average lift is in the same direction as the wind, indicating stability.

The vibration that occurs on an elastically supported cylindrical member is caused by wind-eddies, or "Kármán vortices", on the leeward side of the member. Since the windward face is already cylindrical, an added semi-cylindrical shield should not be expected to eliminate any vibration of this sort that might be present. The writer does not claim that wind-eddy vibration was necessarily the principle cause of the intermittent "bouncing" of the bridge during its months of use, but the possibility appears worthy of consideration.

BLAKE D. MILLS, JR.
Mechanical Engineering Department
Massachusetts Institute of Technology
Cambridge, Mass.

Semi-Rigid Connections

Sir: The authors of the article entitled "Design Economy by Connection Restraint" (*ENR*, Oct. 10, 1940, p. 484) wish to reply to the letter sent in by Prof. Harold E. Wessman (*ENR*, Nov. 21, 1940, p. 671).

The authors agree with Professor Wessman in that the proposed method of design applies most advantageously to the top and seat angle connection insofar as riveted construction is concerned, and they should have pointed this out in their article. The connection which attaches only to the web of the beam does have a definite degree of semi-rigidity but tests indicate that it is insufficient to effect any great economy.

The top and seat angle type of connection is used by many designers wherever possible, even when wind bracing is not required, in preference to the beam web connection. The use of a seat angle facilitates erection, and standardized details for this type of connection are covered on pages 155

and 250 of the 1937 edition of the A.I.S.C. Handbook on Steel Construction. Details are not as yet available regarding just how much semi-rigidity any particular connection can be counted on to develop, although present tests indicate that the substitution of a $\frac{3}{4}$-in. top angle for the usual $\frac{5}{8}$-in. angle and the addition of rivets in the top angle will effect the desired semi-rigidity.

The actual procedure of design must be based on:

(1) Actual experimental knowledge of the relation between angle change and moment for a particular connection.

(2) Application of this knowledge to the most critical connection of loading which "may" occur in the building.

This is the procedure recommended by the authors and if properly carried out it will satisfy Professor Wessman's criteria that the designer consider "what may happen rather than what usually happens."

The proposed design method if adopted would represent a step from admittedly incorrect design assumptions toward a more realistic viewpoint conforming more closely with what actually happens. Conversation with several practicing structural engineers and several letters received since the publication of this article lead the authors to believe that the proposed design method is a step toward filling a real need in structural engineering design. The article itself must of course be supplemented by experimentally determined information regarding the riveted or welded connections in question.

BRUCE JOHNSTON
Assistant Director
Fritz Engineering Laboratory
Lehigh University, Bethlehem, Pa.

Airbase Construction

Sir: In the Oct. 24 issue of *Engineering News-Record*, which is devoted to defense construction, there is one error in the article pertaining to our landplane runways. The base course is mixed in a traveling plant and not in a central plant. The hot mix will be mixed in a central plant.

L. N. MOELLER
Commander (CEC) U. S. Navy
Officer in Charge of Construction
Naval Air Station, Corpus Christi, Tex.

Another error in the article concerning airbase construction in the Oct. 24 issue occurred on p. 550. The figure of 200 lb. of fine slag per square yard of pavement should be 20 lb.—EDITORS.

AERODYNAMIC TERMS EXPLAINED

Several inquiries by readers indicate uncertainty about the meaning of such aerodynamic terms as drag and lift when used in discussion of wind action on bridges, as in Dr. von Kármán's letter on the Tacoma Narrows collapse (*ENR*, Nov. 21, p. 670). Many of the terms were defined and used in a series of articles on "Aerodynamics and the Civil Engineer", by W. Watters Pagon, of Baltimore, published in *Engineering News-Record* in 1934 and 1935*. For present purposes the following condensed explanation may be useful.

An object moving forward against the resistance of the air, or held fixed in an air current, experiences a force tending to move it backward and usually also an upward or a downward force. These forces may also tend to turn the object about its support. Precise determination of their amount is most important for airplane wings, which therefore are the subject of extensive wind tunnel tests. In such tests a profile or cross-section of the wing, called an airfoil, is fixed on supports in the wind tunnel and subjected to the action of a wind stream; the reactions developed at the supports of the airfoil are measured by sensitive balances.

The push of the airstream against the airfoil, assumed to be identical with the resistance that the wing experiences in flight, is called its air *drag*. The upward force is called the *lift*, upward pressure being positive lift and downward pressure negative lift. The moment tending to tip the wing forward or backward is the *aerodynamic moment*.

When a flat plate is exposed edge on in a uniform air current of moderate velocity it experiences only skin friction, and no moment to displace it out of the air stream. But when the plate is tipped up or down slightly it is likely to be displaced suddenly by the aerodynamic moment resulting from concentration of lift near the front or *leading edge*. The point of application of the resultant force is termed the *center of pressure*, and it moves along the plate with change in angular position. When the plate has a curvature from front to rear, and especially when, like a wing section, its curved profile tapers from a rounded forward edge to small thickness at the rear, the travel of the center of pressure is greatly modified. Regardless of profile, however, the lift, drag and moment change with every change in position of the plate or airfoil; in other words, they vary with the *angle of attack*. This designation is usually applied to the angle between a wind direction and the *chord* of the airfoil, that is, generally the straight line joining front to rear edge.

A bridge deck exposed to a side wind is somewhat analogous to an airfoil in a wind tunnel. The lateral wind pressure corresponds to the drag, the upward or downward wind pressure on the deck corresponds to positive or negative lift, and the torsional moment tending to twist the deck around its longitudinal center line corresponds to the aerodynamic moment.

In his discussion of possible wind effects on the deck of the Tacoma Narrows Bridge (*ENR*, Nov. 21, p. 670) Dr. von Kármán assumed, as a generalization from wind tunnel tests on airfoils, that the aerodynamic moment might be computed as though the lift were concentrated one-fourth of the deck width back of the windward edge or leading edge, in other words at the *quarter chord point*.

Winds exceeding a certain limiting velocity have been observed to give rise to fluctuating pressures. Investigation shows that these correspond to small eddies that form between the airfoil surface and the continuous filaments of wind sweeping past the surface. The wind draws these vortices along and creates new ones behind them, and in this action the irregular turbulence at the surface induces erratic and rapidly varying pressures. At still higher velocities these vortices disappear and are replaced by a general turbulence.

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* The series consisted of the following eight articles:

What Aerodynamics Can Teach the Civil Engineer	Mar. 15, 1934 p. 348
Vibration Problems in Tall Stacks Solved by Aerodynamics	July 12, 1934 p. 41
Drag Coefficients for Structures Studied in Wind-Tunnel Model Tests	Oct. 11, 1934 p. 456
Wind-Tunnel Studies Reveal Pressure Distribution on Buildings	Dec. 27, 1934 p. 814
Vortices, Eddies and Turbulence as Experienced in Air Movements	Apr. 25, 1935 p. 582
Engineering Meteorology	May 9, 1935 p. 665
Wind Velocity in Relation to Height Above Ground	May 23, 1935 p. 742
Using Aerodynamic Research Results in Civil Engineering Practice	Oct. 31, 1935 p. 601

EDITORIALS

VOLUME 125 NUMBER 25

December 19, 1940

Access Roads First

SCORES OF ARMY AND NAVY BASES, training camps and industrial plants having defense contracts are being rushed to completion without proper provision for highway access. As Thos. H. MacDonald, head of the Public Roads Administration, pointed out last week before the Asphalt Conference in Dallas, these access roads are more important at the immediate moment than the much-discussed strategic military highway network. He stated that 2,900 miles of access and reservation roads, estimated to cost $200,000,000, are needed to serve the 175 defense projects already under way. While all the state highway departments are cooperating in planning and designing these roads (despite the fact that they are almost solely for military use) most of the states are kept from putting such roads under construction by lack of funds that can be used for such purposes. In a few isolated instances the WPA has been able to provide funds, but it cannot possibly meet a problem of this magnitude with the speed that is required. Already, neglect of this vital link in the defense program is creating intolerable congestion on the highways near the projects. This situation calls for prompt action by Congress in providing adequate funds that can be used by the state highway departments to build the roads with the greatest possible speed.

Strong Walls

RECOGNITION OF THE PART played by walls in the lateral resistance of steel-frame buildings gives special distinction to the design of the Hoover Tower. Walls, though flexible tranversely, are stiff in their own plane, and therefore constitute the essential web members or shear-resisting elements in virtually every frame-and-wall building. Their function is particularly prominent in earthquake shock. Because of their rigidity they come into play first, the frame taking up the load only after the walls have been put out of action by cracking, which generally happens at an early stage. Since cracked walls mean a largely ruined building, the choice lies between trying to isolate the walls from shear effects by placing expansion and slip joints around the panels, and the alternative course of making the walls strong enough to take the earthquake load without cracking. The latter course was chosen by the engineers of the Hoover Tower, very wisely too it would seem. Reinforcement is, of course, essential for this purpose in a brittle material like brickwork or concrete, but the proportions of the Hoover Tower design indicate that the net increase of cost is small, since the frame is relieved of much unnecessary duty. The design principles applied to this tower invite more general application. Walls need not be confined to their traditional functions, but can and should be put to more modern use in resisting wind and earthquake attack.

Water for New York

QUANTITY AND QUALITY are yardsticks for measuring the usefulness of a water supply. This is clearly evidenced in the development of New York's new Delaware project, which will add a half-billion gallons daily to the city's supply. How this vast quantity will be made available has been described in a series of articles, the concluding one of which appears in this issue. Significantly, this final article is devoted to the methods by which the water will be safeguarded in quality. Because the supply is of high quality at its source, filtration facilities will not be needed. But many other measures will be employed to insure consistent delivery of a pure and uniform product. These include a program of watershed sanitation and inspection, long detention in reservoirs, copper sulphate and turbidity treatment, aeration and multiple chlorination. Long experience with similar measures applied to the Croton and Catskill systems confirms the effectiveness and reliability of these quality safeguards, attested by the very low typhoid rate for New York City. Measured by quantity or quality standards, the new Delaware supply is planned to meet the most exacting requirements.

Cross-Connections Again

CROSS-CONNECTION EVILS are dramatized once again in the situation at Rochester, N. Y., where half of the city was served with "grossly polluted" water last week when a valve connected with a river fire supply was unwittingly opened. As described in our news section this week two facts stand out as a result of this unfortunate occurrence: (1) connec-

tions between potable and non-potable sources of supply are an invitation to disaster; and (2) the lack of complete, up-to-date records of the distribution system is a dereliction of duty. It can be admitted that a real difficulty exists in finding and eliminating connections that were made in years gone by; it is a job calling for the sleuthing of a Sherlock Holmes coupled with the fervor of a reformer. However, there can be no excuse for inadequate records; the valve which caused the trouble at Rochester was said to be listed in the record book merely as "FC" (flange connection), and no other identification was employed. The real test of the efficiency of a water-supply system is not in the purity of the product leaving the treatment plant but in the state in which it leaves the consumer's tap. A cross-connection and unrecorded distribution system data, as dramatized at Rochester, can undo the work of the finest purification plant.

Adding to the Record

OUR LIMITED STOCK OF DATA on endurance of concrete in seawater receives an important addition in L. C. Hammond's report on a survey of 19 New York structures up to 37 years old. The reported findings strengthen two beliefs: one that excellent seawater resistance can be obtained from concrete, the other that faults in the makeup or placing of the concrete are causative or contributory factors in early disintegration. Unfortunately the influence of such faults cannot be evaluated precisely, partly because inspection is not always able to tell whether concrete is good or bad, and partly also because there is no definite criterion of what constitutes good concrete. Consequently the disintegration of concrete that looks good (or on the basis of its construction record is believed to be good) is often regarded as evidence that the cement or the aggregates were inferior; and even the fact that some parts of the disintegrated structure may show no trace of disintegration is not accepted as proof that the component materials are satisfactory. For the present at least surveys like the one now reported give us the best information. If sufficient evidence of this kind is brought together, through careful and impartial inspections, we should arrive at a close approximation to certainty. The long-time study of cement performance in concrete, now being planned by the Portland Cement Association and an eminent board of experts, will include structures in seawater and thus should also improve our knowledge of concrete endurance. In the meantime every added fact recorded lays more emphasis on the indispensable need of dense concrete and thorough steel embedment in seawater structures.

Costly Rapid Transit

THE WORLD'S MOST COSTLY SUBWAY went into service last week, the 6th Ave. line of the Independent Division of New York's Rapid Transit System. A little over two miles long, the subway cost $59,000,000 or about $27,000,000 a mile. Many factors contributed to this high cost; footings for the now-abandoned and demolished 6th Ave. elevated railway; the tubes of the Hudson & Manhattan Ry. in the same street for much of the way; a maze of existing underground stations and railroad lines at Herald Square; cross-town subway and railway tunnels; the shafts of a water supply tunnel; and bad rock conditions all the way.

Looking backward at the record of increasing cost of transit facilities in New York and forward to the future requirements of that city and of other cities across the country there is good reason to speculate as to whether better city planning in the past would have eliminated some of the causes of the high cost of the 6th Ave. subway. Only in the matter of demolition of the 6th Ave. elevated can one speak with any assurance; the whole cost of underpinning this doomed line could well have been saved. On such matters as the position of crossing subway lines, however, earlier builders should not be strongly indicted for failure to add to what then seemed to be high costs to provide for the very remote possibility of replacing the 6th Ave. elevated with a subway.

Subways are expensive and their costs increase in direct proportion to the other services that are in the way of their construction. Cities, such as Chicago, where the first stages of an underground system are under development could wisely plan all major changes in sewer and water lines and in electric duct systems to conform to expected subway locations. Beyond this, planners must accept the fact that rapid transit is going to be costly.

ENGINEERING NEWS-RECORD
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Earthquakes

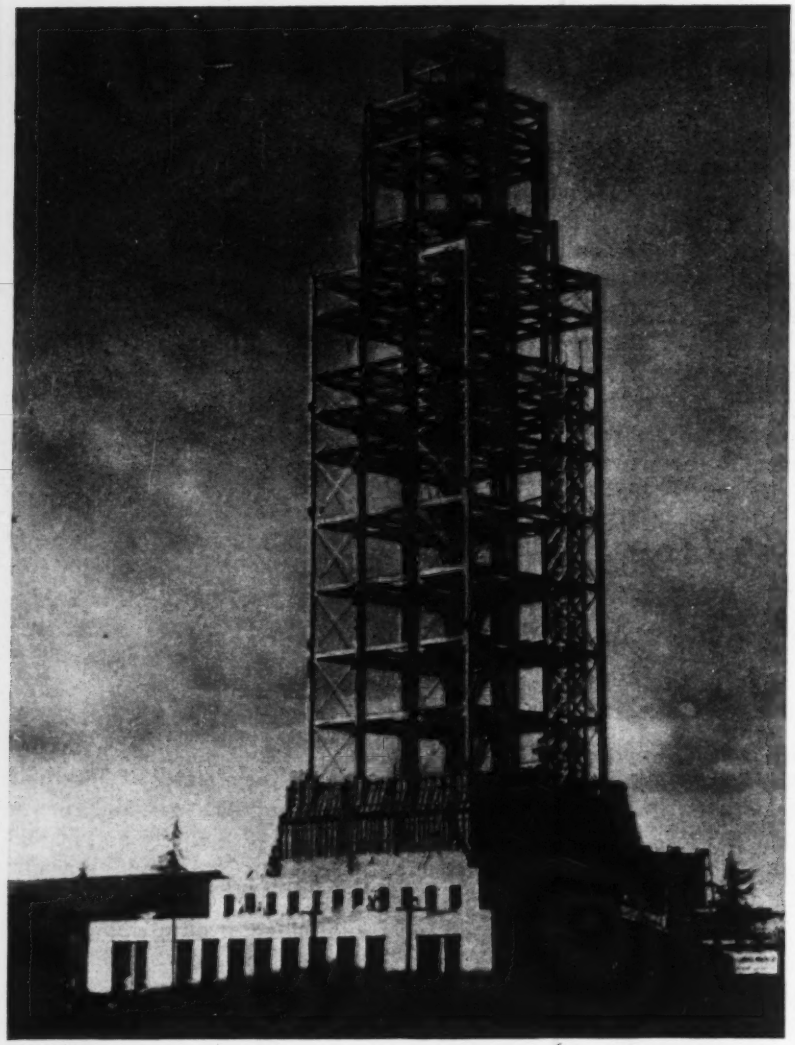


Fig. 1. Steel tower of Hoover Library before pouring began on the concrete walls.

***Contents in Brief**—The 279-ft. tower of the Hoover Library at Stanford University has a steel frame designed to carry wind loads, reinforced concrete outer walls to carry earthquake loads. At second-floor level, shears from the tower are distributed over a base five and a half times the tower area. Earthquake precautions added little to construction costs.*

THE HOOVER LIBRARY on War, Revolution and Peace at Stanford University, Calif., is only 2 miles from the active San Andreas fault, and as its function is to provide a permanent repository for valuable records precautions were taken to safeguard the structure against earthquake damage. For monumental effect the main element of the structure is formed by a tower 52½ ft. square and 279 ft. high; earthquake-resistant design of this tower was the principal problem.

Though carried by steel framework, the tower is enclosed with reinforced-concrete walls designed to resist earthquake stresses, while the steel frame is braced to resist wind loads only. To carry the horizontal forces from the tower to the outer walls of the two-story structure at the base and thereby distribute them over the 122-ft. square of the base, the roof of the base structure was made 6 in. thick instead of the 4 in. that would have served other purposes.

A maximum force of 0.1g was the basis of design. This force must be resisted by the concrete outer walls, as stress analysis indicated that because of their stiffness these walls would take 98 per cent of the horizontal earthquake force even though the steel were designed strong enough for earthquake stresses. Were the walls made light and dependence placed on the steel frame, a severe shock probably would damage the walls badly, while with the actual design even a shock of 0.1g intensity is not expected to damage the walls seriously, and what might be heavy repair costs will be avoided.

Above the fourth floor (about 57 ft. above ground level) there are practically no construction features whose function is primarily earthquake resistance except some heavily reinforced piers at the 11th floor to carry shears and bending stresses resultant from earthquakes. Even below the fourth floor, construction items that are to be charged to the earthquake account are not costly. Chiefly they are: (1) an additional 12 in. of wall thickness around a 52½-ft. square extending from the 60-ft. height down to the foundation. (2) a 2-in. additional thickness of concrete in the second-floor roof, (3) extra thickness and reinforcement in the exterior walls below this level, and (4) added section in some columns and walls, a relatively minor item. Altogether the cost chargeable to earthquake resistance is quite a small percentage of the overall building cost. On the other hand the labor of design was greatly increased. Provision for the horizontal forces added largely to the necessary analyses and the detailing of members and connections.

As the tower space is to be used for library stacks and will be air con-

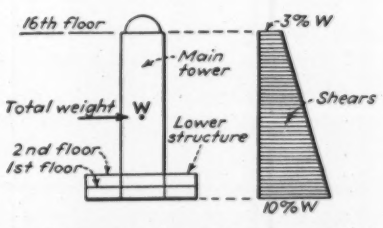


Fig. 2. A percentage of total weight of this 279-ft. high tower building was used in figuring earthquake stresses for all levels.

Influence Tower Design

ditioned, it has no windows except in the 11th story. The absence of windows made it possible to use full diagonals between columns in the corner panels, and thus reduce the amount of steel in columns and spandrel girders.

In its main part—up to the 14th floor—the tower is square, and for architectural effect is tapered from 52½ ft. on a side at the 4th floor level to 50½ ft. at the 14th floor, by giving the outer walls a batter of 1 ft. in 137 ft. of height. The 14th and 15th stories change from square to octagonal in plan, with elaborate architectural development. The 16th floor supports a 45-ft. dome, surmounted by an octagonal lantern 23 ft. high.

From basement floor to top of lantern the building has a volume of 1,131,000 cu.ft. The total floor area is 75,000 sq.ft., not counting 20,800 sq.ft. of mezzanines carried on bookstack construction. The roof area totals 15,500 sq.ft.

The concrete walls of the tower above the 4th floor are 8 in. thick and have pilasters 12 in. thick superimposed on the outer wall surfaces. Below the 4th floor the wall thickness is 12 in.

The concrete walls of the lower structure surrounding the tower are 12 in. thick in the basement story, and 10 in. in the first story. The main tower rests on a reinforced-concrete mat 61 ft. square and 5½ ft. thick, but the surrounding lower structure has its exterior walls and columns carried on continuous foundations, while the interior columns rest on independent footings.

The floors which support book stacks are designed for a live load of 175 lb. per sq.ft. They are two-way slabs 4½ in. thick with spans of 8.25 ft. Due to the heavy live load, the steel beams encased in concrete which support these floor slabs are expected to deflect, relative to the practically unyielding exterior walls, enough to produce large bending moments in the slabs at the walls.

The dome, 45 ft. in diameter, is an

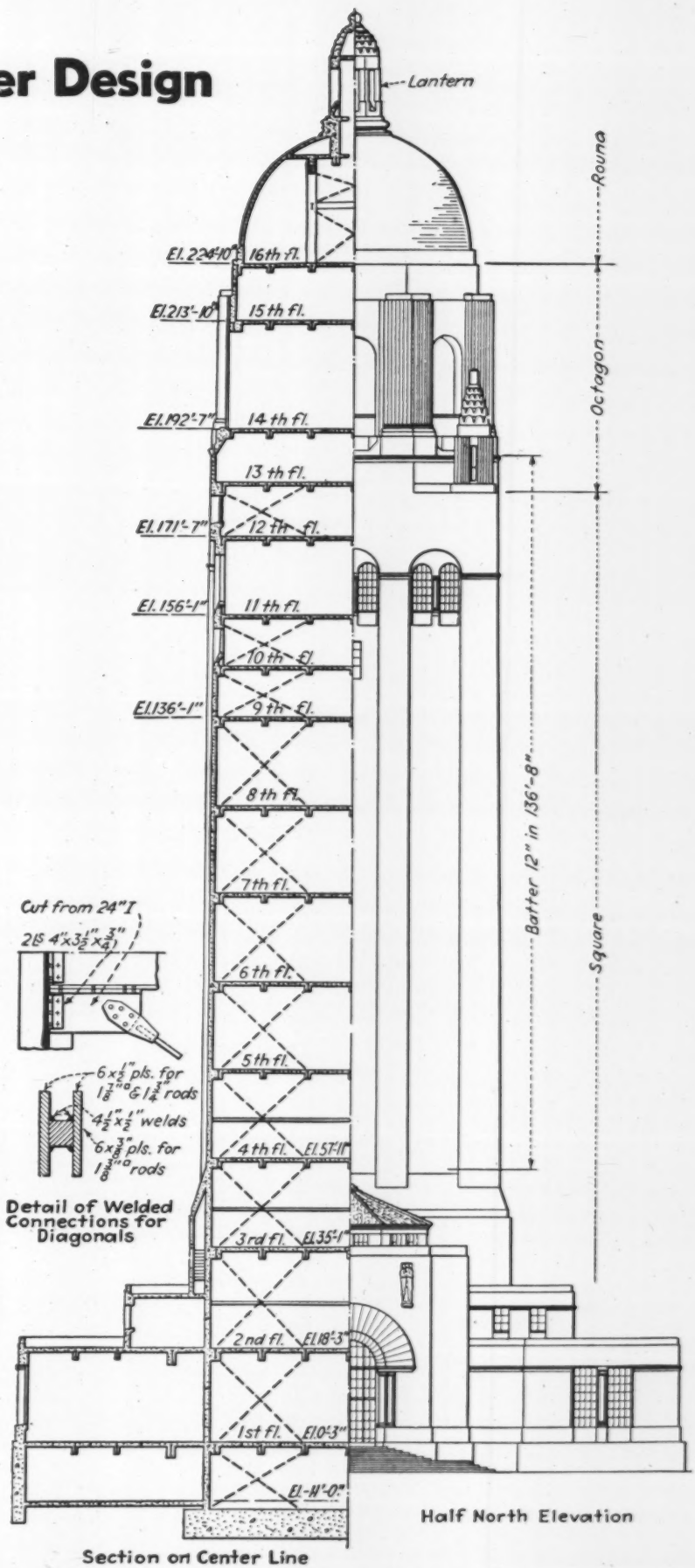


Fig. 3. Half elevation and half section. Note diagonal bracing and the two-story structure around the base that distributes shears over a larger area.

almost spherical shell of shotcrete, 4½ in. thick, resting on four interior columns near the top, stiffened by a circular concrete platform which is bonded around its circumference to the dome shell and also to the four columns. The shortening of these columns under live loads will produce a forced deflection in the dome shell, which was considered in the design.

Horizontal forces

The steel frame of the tower is designed to resist a wind load of 20 lb. per square foot on any vertical projection at not more than one-third above normal unit stresses. At the 11th and 14th stories, where openings prevent use of diagonal braces, the wind forces are resisted by bending in the columns and girders. Here all members are designed to resist the combined bending moments due to vertical loads and lateral forces. Although wind loading will be quite within the strength of the concrete walls, including provision for it in the steel framing gave wind protection in the event windload of maximum intensity occurred against concrete forms before concrete wall strengths had been developed.

In regard to stresses developed by earthquakes, the problem was attacked from the dynamic standpoint. It was assumed that when the structure is subjected to a series of earth shocks it will be compelled to execute vibrations and thus will be responding to an earthquake rather than resisting it. The analysis of earthquake effects therefore was an endeavor to estimate the distortion of the structure and to provide for the resulting stresses.

Analytical and experimental investigations showed that three or more earthquake waves coincident with one of the natural periods of the structure are sufficient to set up considerable vibrations. Experimental work on a sixteen-story model by Lydik S. Jacobsen and Robert S. Ayre (Bulletin Seismological Soc. of Am., Vol. 28, 1938) was used as a basis of reference.

Considering the response in the first three modes of vibration of the building, the distribution of maximum shears along its height was assumed to lie within a trapezoid (Fig. 2) with a shear of 10 per cent of the total weight of the structure at the bottom and 3 per cent of total weight at the top (base of the dome). Note that W in Fig. 2 is total weight of the structure including permanent live loads (as books on the shelves), not weight of only that portion above the plane under consideration. The 10-per-cent-W value is based on economic considerations, but the trapezoidal variation is based on studies of probable dynamic behavior of the structure. The shear in the 15th story is 101 per cent of the superimposed weight, that in the 14th story is 61 per cent of the superimposed weight.

As already stated, practically all of the shear is resisted by the stiff concrete walls. Unit stresses 50 per cent higher than normal values were permitted in providing for earthquake loads.

At the 1st and 2nd floor levels (see Fig. 2) any movement of the main tower is arrested by the concrete slabs, which, while yielding, still transmit a portion of the stresses to the exterior walls of the lower structure; these walls will also yield under stresses. Thus the amount of horizontal force transmitted from the tower to the exterior walls of the lower structure is expected to be determined by a combination of factors including the elastic properties of the 1st and 2nd floor slabs, the main tower walls and the exterior walls of the lower structure.

Fenestration

Except for small windows or air vents in the stairway at the rear, there are no windows in the tower up to the 11th story, which has windows all around. There are no windows in the 12th and 13th stories, and the 14th story marks the change in plan to the octagonal base for the surmounting dome. The absence of windows in most of the tower affords an ideal opportunity for diagonal sway bracing in wall panels.

All diagonals have turnbuckles, placed just above floor level and left accessible in the completed structure so that they can be tightened when necessary. In erection, field bolts were placed in the gussets and the turnbuckles were then tightened enough to draw them firmly into position before diagonal and gussets were riveted together. As the riveting thus was done with rod and gusset in final position, no secondary stresses will be introduced when the turnbuckle is later tightened.

On completion of concrete pouring, these rods were found to have been loosened by the shortening of the columns, and they were then tightened (under extensometer control) to an initial stress of 5,000 lb. per sq.in. This is expected to bring the diagonals more quickly into play in the event of an earthquake.

The wall batter of 1 to 137 was accomplished (with vertical columns) by variations in the spandrels and by an offset at the 4th floor level. Maximum distance from face of pilasters to center line of columns is 3 ft.

Foundation

The foundation is sand, clay and gravel which load tests show to be almost perfectly elastic within the range of loading. The maximum combined earthquake and direct loading on the foundation beneath the 5½-ft. concrete mat which underlies the tower is about 6 tons per square foot. This loading was decided upon after static and dynamic load tests were made on the foundation.

A seismological study of the foundation was made by the Seismological Field Survey, of U. S. Coast and Geodetic Survey. The same organization determined the natural period of the building repeatedly as concrete pouring reached each successive floor level. Although results of these tests will not be announced until the analysis is completed, it is reported that the natural period materially decreased as the concrete level rose.

Hall & Pregnoff, structural engineers, designed the structure. Arthur Brown, Jr., and John Bakewell, Jr., were the architects and Geo. Wagner carried out the $550,000 contract for construction. All the foregoing are San Francisco firms.

Plasticizing Wood

During the course of seasoning experiments at the Forest Products Laboratory of the U. S. Forest Service, Madison, Wis., oak soaked in urea and then dried became plastic and capable of being bent, twisted and compressed when the temperature reached 212 deg. F. When cooled to normal temperature hardness and rigidity were resumed. Impregnated wood chips or sawdust act similarly, forming a thermoplastic material. Molding to shape large plywood sheets is suggested, as well as a variety of wooden articles.

Wharf Built in an Unstable Bank

C. Glenn Cappel
Vice President, W. Horace Williams Co., New Orleans, La.

FOR MANY YEARS, the General American Tank Storage Terminals Co. at Goodhope, La., repaired and rebuilt a wood-pile wharf that stood in one of the most unstable stretches of bank to be found on the lower Mississippi River. Piles for the wharf were driven down 30 to 40 ft., but each year the structures moved bodily out into the river with the receding of high water. Now the structure has been rebuilt with steel piles driven so deep that the unstable bank will slip past them without moving them.

The cause of the slipping bank appears to be a combination of erosion and the weight of silt deposited during high water. As the water goes down and the weight of the new material become effective, the bank to a depth of 60 to 65 ft. begins to move out into the river and continues until it reaches a new state of equilibrium. There appears to be no definite plane of slippage but the maximum depth of movement is around minus 70.

After considerable study, the engineers engaged by the company to take charge of reconstruction determined that the proper principle on which to base the design was that of putting piles deep enough to be below any plane of slippage and strong enough to stay in place while the earth moved or flowed past or around them. To attain that stability, 30-in. WF 108-lb. beams 150 ft. long were chosen for piles, the piles to be driven to about minus 120. This meant a penetration ranging from 80 to 120 ft. The piles were driven so as to offer only the flange surface to the moving earth.

The approach bents were spaced 40 ft. on centers to allow maximum opening for passage of drift, and the entire structure was tied together thoroughly with longitudinal steel collars consisting of 18-in. I-beams placed at low water. No cross-bracing was used in the longitudinal elevation of the approach, but in cross-section the two piles in the approach bents were thoroughly braced with battened 12-in. channels. The superstructure of the dock is all steel except the decking of creosoted wood.

The entire structure is welded for full development of the strength of the members and all pile splices have a 25 per cent excess over the pile section.

The piles were driven in two sections, the first 75 ft. being driven down near water level, then the top section was set in place and the splice made, after which the pile was driven to final penetration, using a hammer delivering 30,000 ft.-lb. per blow. Driving resistance was very uniform, averaging 30 to 40 blows to the foot for the last 40 ft. of penetration. The record of driving indicates that our judgment was correct as to the maximum depth of the plane of slippage.

The berthing face of the new structure was set about 50 ft. nearer to the shore than the face of the old wharf and the top of the bank was dredged to provide necessary channel depth.

The mooring dolphins are a most interesting element of the structure. Each is made up of a cluster of four 16x11½-in. WF 88-lb. beams 150 ft. long driven to form roughly a 39-in. square. They were driven in contact and then welded together above waterline. Timber chafing strips are set in the outer recess, as shown in Fig. 2. Each cluster is braced back to two 16x11½-in. heel piles.

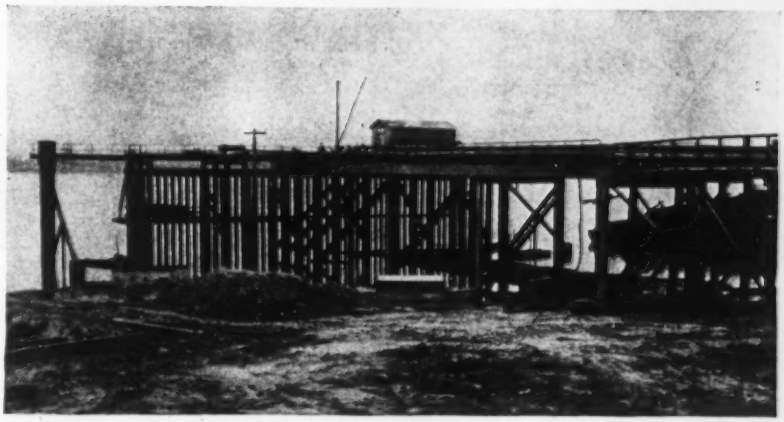


Fig. 1. New wharf is supported on H-section piles 150 ft. long. The part of the old timber wharf that could be retained is shown at the right.

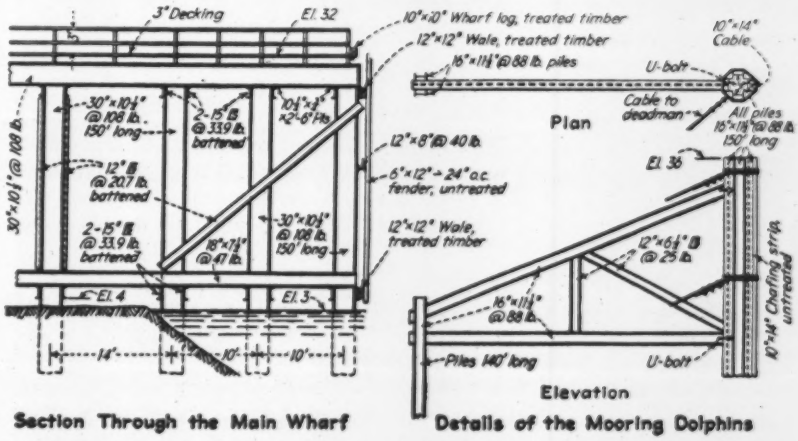


Fig. 2. Details of the main wharf and mooring dolphins. The wide-flange beams used as piles for wharf are set to present minimum of resistance to bank movement.

Fig. 1. Start of depressed grade elimination of Winnetka, Ill., a residential suburb of Chicago.

Three-Mile Depressed Grade Elimination

Sidney Ames Huguenin

Formerly Chief of Squad, Engineering Section, Region No. 2
Public Works Administration, Chicago, Ill.

***Contents in Brief**—After 35 years of planning and negotiation, the parallel tracks of the Northwestern Ry. and the North Shore Lines through the populous residential suburb of Winnetka, north of Chicago, are being put into a three-mile-long cut as one of the largest grade separation projects in the country. Most interesting feature of the work is handling both railroad and street traffic during construction, involving an additional set of temporary tracks, use of each other's right-of-way by the two railroads and temporary highway bridges over the cut.*

PLACING the four parallel tracks of the steam-operated Chicago & Northwestern, and the Chicago, North Shore & Milwaukee electric railroad in a common cut three miles long on the original rights-of-way through Winnetka, Ill., is one of the largest grade elimination projects now in progress. Grade separation in an urban area is always complicated, not only in engineering but also in financial and social aspects. In this instance, which involves two heavily traveled railroads, the traffic on which could not be interrupted, three separate municipalities whose local street traffic could be only partially diverted, the Public Works Administration with its deadlines for starting and completion, and financing the project by special assessment, the complications have indeed been multiplied. Construction difficulties centered around the excavation of the cut, without danger to adjacent tracks, placing some of the tracks in the first excavated width of cut for immediate train operation and working alongside these tracks in widening the cut to full width. During construction operations the railroads are shifted from one set of tracks to another, complicated by the Northwestern's left-hand operation on double track.

Winnetka is one of the series of communities that form the suburban area known as Chicago's North Shore. With population equally distributed on both sides of the railroads, with numerous street crossings and with a high ratio of automobiles to families, there was an unusually heavy flow of traffic across the tracks. Coupled with heavy traffic on the railroads, the situation was dangerous to an extreme. Although all crossings were protected by gates or automatic signals there were, in the last 25 years, 31 deaths and 38 injuries in crossing accidents in Winnetka alone.

As long ago as 1906 a comprehensive plan for separating the grades was proposed by the Winnetka village engineer. In 1919 separation was advocated by the Winnetka Plan Commission as an improvement to be attained at the earliest possible opportunity, but it was not until the summer of 1938 that the village found itself in a position to proceed.

Engineers were retained to study the several plans previously proposed, coordinate the many and various ideas on the subject, and prepare a new plan acceptable to all of the interests concerned. An application for government aid was filed with the PWA in August, 1938, and an allotment received in October of that year. A postcard referendum in September having shown a majority of citizens in favor of the project, the government's offer of financial aid was accepted and working drawings and specifications were prepared immediately. The first contract was let

Fig. 2. One of several temporary highway bridges on the project which were lengthened as the cut was widened out in progressive stages. Tracks in the cut are the final C. & N. W. line, but are used temporarily by the C. N. S. & M. electric line, which requires temporary trolley installation; temporary C. & N. W. tracks are at grade to the left.

Dec. 16, 1938, two weeks ahead of the deadline set by PWA for starting the project.

Unusual financing

One of the most unusual features of the project is the method of financing. It was agreed that the cost to the railroads should approximate the cost of the crossing protection, and that the village should bear the remainder of the cost, less that which would be covered by the government grant. The railroads were not agreeable to making a cash contribution of the full amount of their share of the cost, so means were sought to permit them to pay in installments. The special assessment method provided sufficient flexibility in dividing the cost as desired, and spreading it over a long period of time. To provide the necessary cash the village issued general obligation bonds to cover its share of the assessment and the government purchased sufficient special assessment certificates to cover the total assessment on the railroads.

As far as known, only one other grade separation project has ever been financed by this method and that was a much smaller job. This financing arrangement has its drawbacks in that it allows little room for adjustment of the design to meet unanticipated conditions, and is rather complicated from the legal angle, but it has worked quite satisfactorily in this case. The Tower Road bridge, the paving in connection therewith, and the paving of Winnetka Ave., under the railroad bridges, are to be paid for by the county, since these two roads are county highways.

In designing the project full consideration was given to the ultimate aim of separating the grades throughout the North Shore area. Wilmette and Kenilworth to the south, lie on the so-called Chicago plain, but Winnetka and the communities to the north lie at elevations from 40 to 60 ft. higher. Accordingly the the north lie at elevations from 40 tracks to the south and depression to the north, the transition occurring near Willow Road, Winnetka. To meet the grades required by the ultimate project it became necessary to extend the present project well into the villages of Kenilworth on the south and Glencoe on the north.

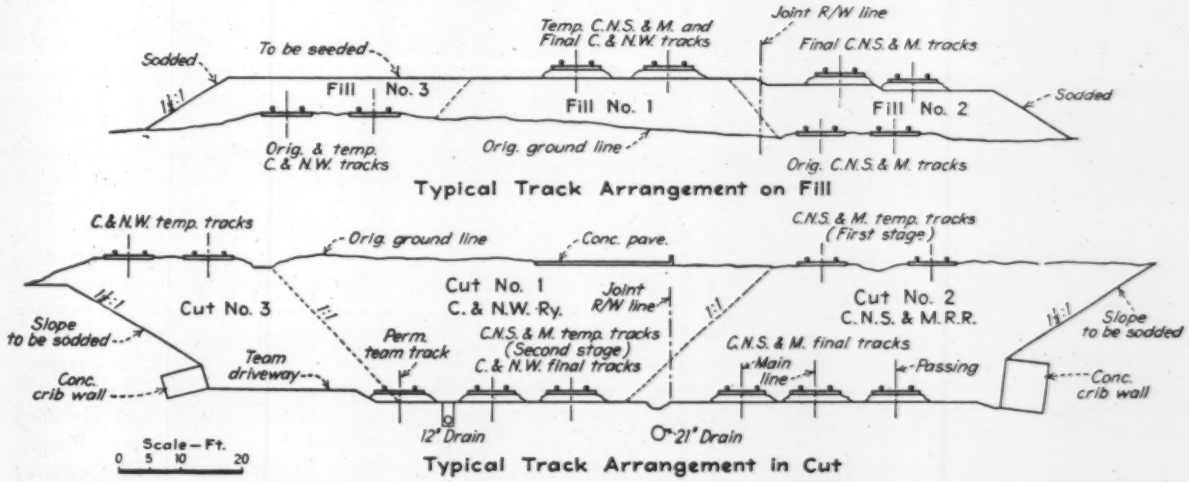


Fig. 3. Typical track arrangements in cut and on fill. In general the C. & N. W. tracks were left in place or moved over as temporary line while final C. & N. W. tracks were installed in the first cut to be used temporarily by the C. N. S. & M.

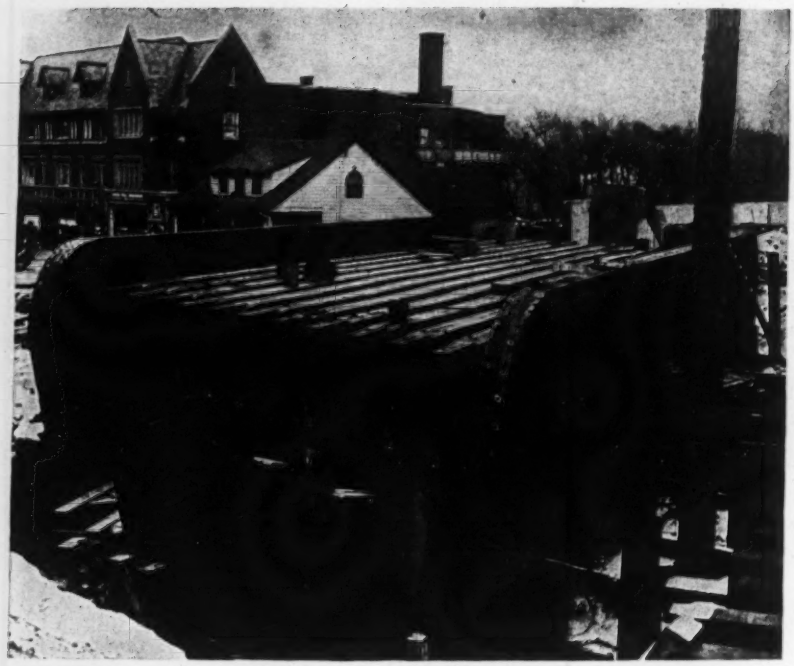


Fig. 4. Winnetka Ave. was placed in an underpass of rigid frame design.

No immediate provision has been made for additional tracks on either railroad except that the highway bridges and pedestrian underpasses have been designed so that the addition of a third track for the Northwestern would require only minor changes in abutments and wing walls. A team track and driveway for the Northwestern is provided along the west side of the tracks between Elm St. and Tower Road, and a passing track for the North Shore provided on the opposite side of the right-of-way in the same stretch.

Structural features

From the structural point of view the most interesting features are the retaining walls and the railroad bridge at Winnetka Ave. Great effort was expended to provide structures of pleasing appearance, in view of the high class character of the neighborhood. Indian Hill, as the district is called, is supposed to be the original home of the Pottawattami Indian tribe, so Pottawattami insignia have been utilized for the decoration of the structures. The principal retaining wall is of the cantilever type, T-shaped in section. It was poured, after completion of the footings, in sections 50 ft. long with hidden construction joints. Most of the footings were poured under ordinary conditions, but all of the wall sections were built during winter. Panel forms, generally 8 ft. wide and the full height of the walls, were handled by crane; concreting was done by paver and crane. The back of the walls and the joints were carefully waterproofed and all exposed surfaces were rubbed.

The railroad bridge is really two separate structures, that for the C&NW being designed for Cooper's E65 loading, the other for E50. Rigid frame design was adopted to conserve headroom and for architectural appearance. Foundation conditions were excellent, piles showing a loading in excess of 120 tons under test. The thrust of the rigid frame was met by piles driven at the angle of the resultant stress. The design load on the piles was maintained at 60 tons.

The pedestrian underpasses at this end of the project presented no unusual problems. The Sunset Road underpass was lowered so as to pass under the street along the retaining wall because the principal users of this subway will be high school students not seeking access to the railroad station.

The highway bridges are all of the continuous beam deck type with, except in one instance, shallow abutments on piles and concrete piers. The Pine St. bridge which crosses the C&NW team track and driveway and the North Shore passing track, is carried on vertical-faced, buttressed abutments to the bottom of the cut. A main highway parallels the railroads, and for the entire length of the cut is immediately adjacent to the western edge of the right-of-way. To avoid excessive adjustment of the highway pavement and approach grades it became necessary to reduce the bridge clearances to several feet less than the usual 22-ft. standard. As a condition to the approval of the lowered clearances, girder illumination was required. This was accomplished in a rather novel manner by the installation on each bridge pier of a lighting fixture so constructed as to illuminate the girders brightly yet throw no light in the eyes of the approaching locomotive engineers or motormen.

The Woodlawn Ave. pedestrian overpass is a rigid frame, concrete-encased bridge of 134-ft. span. This bridge will be used principally by school children and therefore the approach and bridge handrails are carried to a height of 5 ft. 2½ in. above the walkway and are protected by wire mesh. The entire floor of the bridge and the approach stairs are of non-slip finish. Parapet type lighting is employed with the units set in the lower handrail.

Drainage of the cut is by two concrete pipe sewers, one serving the south and the other the north end of the excavation with new outfall sewers to the lake. One of the sewer outfalls was constructed in tunnel for the first 600 ft. of its length; the remaining 1,200 ft. followed the bottom of a deep and heavily wooded ravine, all on private property. Easement restrictions for this part of the line required that no trees be destroyed and the ground be left in its original condition upon completion of the work. Collecting drains vary from 12 to 36 in. and outfalls from 42 to 36 in.

The catenary bridges to carry the trolley for the Chicago and North Shore are 10 and 12-in. wide-flanged beams with shop connections welded and field connections partly welded and partly riveted. The bridges carrying transmission poles are reinforced with additional bars welded to the flanges of the legs under the poles. Connection of the poles to the bridges is an interesting detail, special care having been exercised to avoid any pockets to collect dirt and water. Appearance again influenced the design of the structures, the H-beam

section being considered more suitable than the usual laced angle type of construction. In fabricating the bridges, the beams were too large to be bent satisfactorily. The outside flange and half of the web therefore, was cut out for the length of the bend, each piece then bent separately and the pieces welded together.

Construction operations

Probably the most interesting angle of the entire project is the construction procedure. The C&NW runs 100 trains per day and the North Shore 110. None of this traffic could be interrupted. As far as highway traffic was concerned, some of the streets could be closed for the duration of the job, but the principal arteries, Winnetka Ave., Oak St., Elm St., and Tower Road, had to be kept open to all traffic and Pine St. to pedestrian traffic. This necessitated bypassing Winnetka Ave. by means of a temporary subway, erecting temporary bridges before closing the other streets, and completing and transferring operations to one line of double track before starting work on the other. Accordingly the work was scheduled in four stages, generally distinct but overlapping in some phases.

The first stage included the construction along the western edge of the right-of-way, of temporary tracks, stations and driveways for the Northwestern. Involved in this operation was considerable alteration to the buildings and sidetrack of a lumber yard north of the Hubbard Woods station. The first of the temporary tracks was laid with new rail. Traffic was transferred to this track as soon as possible and then one of the existing tracks removed and relaid as the second temporary track. The rail of the second existing track was salvaged to be used for one of the permanent tracks. Cutovers were made on Sundays without interruption to traffic.

The second stage covered the construction of the Chicago & Northwestern permanent tracks in the first cut and fill, including the major portion of the sewers, the temporary highway bridges, a temporary trestle for this line at Winnetka Ave., the bypass for Winnetka Ave. street traffic, located at Sunset Road about 900 ft. north of Winnetka Ave., the permanent tracks, a temporary trolley system, and temporary platforms. The temporary bridges are steel beams on wood pile bents with 2x4-in. laminated floors, and wood guard rails. The temporary platforms utilized as far as possible foundation which will serve for the permanent platforms. Upon completion of this work the operations of the North Shore Line were transferred to this trackage and their old tracks removed.

The third stage covers the construction of the permanent Chicago and North Shore tracks. This includes the second cut, which completes the excavation to the eastern edge of the right-of-way, the construction of the retaining walls, the east half or Chicago & North Shore portion of the Winnetka Ave. bridge, the extension of temporary highway bridges, the pedestrian underpasses, and the completion of the drainage system for the cut, the erection of the catenary system and the permanent highway bridges except for the west spans, the laying of the permanent Chicago & North Shore tracks, and the building of the permanent North Shore platforms. The North Shore operations will then be transferred to their permanent location, the temporary trolley system removed, the Northwestern bridge at Winnetka Ave. constructed, the Northwestern permanent tracks realigned and raised to their final grades, the permanent platforms built, and the Northwestern operations transferred.

Included in the fourth or final stage will be the removal of the temporary tracks, the completion of the west spans of the permanent bridges, the removal of the temporary bridges, the building of the stations, the closing of the Winnetka Ave. bypass, the sloping and sodding of the sides of the cut and fill, and the paving of the approaches, bridge roadways and parking areas.

Disposal of the spoil from the cut was a major problem. About one-third of the earth removed was used for fill at the south end of the job, but there remained over 600,000

Features of Winnetka Grade Separation Project

Estimated total cost of project	$3,756,000
Total length of project	3.51 miles
Excavation—main cuts	915,000 cu. yd.
Fill	110,000 cu. yd.
Total track laid	105,700 ft.
Grade crossings eliminated	10
Railroad bridges built	1 (double)
Highway bridges built	7
Pedestrian bridges built	2
Pedestrian underpasses built	4
New station buildings (with platforms)	4
New platforms (CNS in addition to above)	6
Principal Unit Contract Prices:	
Excavation:	
Main cuts	$ 0.59
Retaining wall	.70
Bridge foundations	3.59
Concrete:	
Footings	10.50—16.00
Walls	15.40
Piers, etc	17.95—20.00
Woodlawn Ave. bridge	28.82
Cast in place piles:	
Railroad bridge, per ft.	1.95
Highway bridges, per ft.	3.39
Structural Steel:	
Railroad bridges	.06
Highway bridges	.064— .087
Catenary bridges	.0445

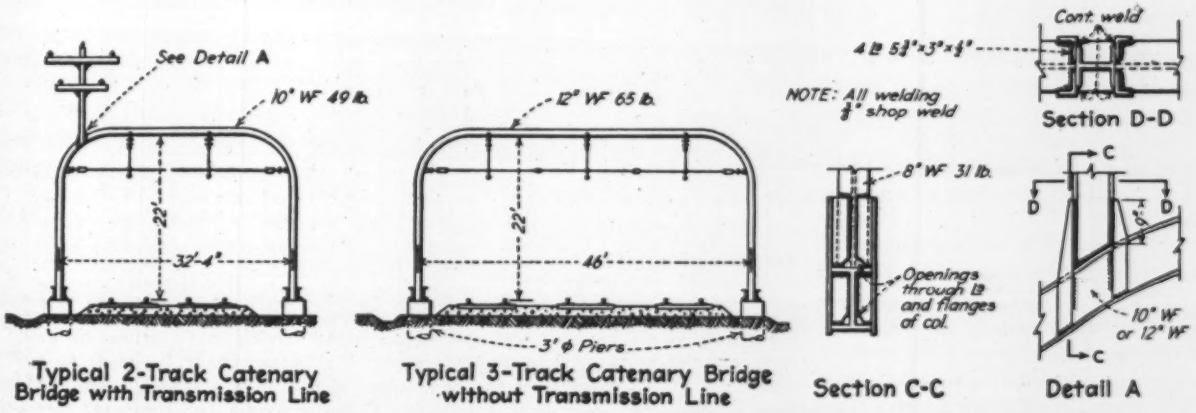


Fig. 5. Unusual catenary bridges for the new C. N. S. & M. line consisted of bent H-beam sections.

cu.yd. of material to be disposed of off the site of the work in a highly developed residential area. The contractor decided to truck the dirt out of the cut and dispose of it locally rather than haul it out by train. To the west of the village is the Skokie Valley, a long marshy area that forms the headwaters of the Chicago River. Drainage in recent years has made the edges of the former marsh a very desirable residential location, and here the contractor found a market for many thousands of yards of fill. The county highway department took many more thousands of yards for stock material for future use, fill in quantity being ordinarily unobtainable in this part of the county. Two 2½-yd. and one 1½-yd. diesel powered shovels and 24 5-ton trucks have handled the entire job of excavation. For part of the time two shifts were operated, but because of objections by the residents, single shift operation was used as much as possible.

Direction

Work was started Dec. 19, 1938; final completion is scheduled for May 29, 1941. The project is under the direct charge of P. E. Conner, village project engineer, Winnetka. The consulting engineers in charge of design are Charles DeLeuw & Company, Chicago. C. N. Bainbridge is supervising engineer for PWA. Principal contractors are: temporary stations, C. E. Carson & Co., Evanston, Ill.; trackwork and permanent highway bridges (except Tower Road), Deckert & Macdowell, Chicago; excavation, drainage, temporary bridges and miscellaneous structures, Minder Construction Co., Chicago; retaining walls and Winnetka Ave. bridge, Suburban Paving and Improvement Co., Chicago; paving, Robert Anderson & Co., Chicago; permanent electrification of North Shore, Street Lighting Service Co., Chicago.

The contract for the Tower Road Bridge, which is being built by the county, has not yet (Dec. 10) been awarded. Contracts for all but one of the nine stations are well under way. The North Shore is doing the electrical work on existing facilities with its own forces, the Northwestern will install their own signal work and the Village of Winnetka is making adjustments to the municipally owned utilities. All sewer and water relocations were included in the excavation contract.

Servicing Signs with a Single Truck

P. T. Martin

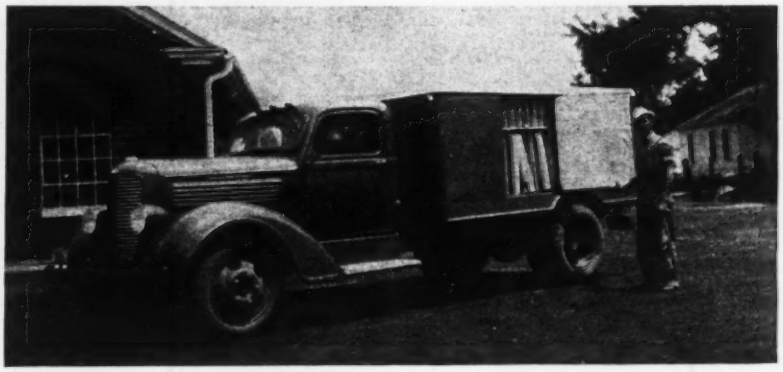
Sign Department Engineer, Iowa State Highway Commission
Council Bluffs, Iowa

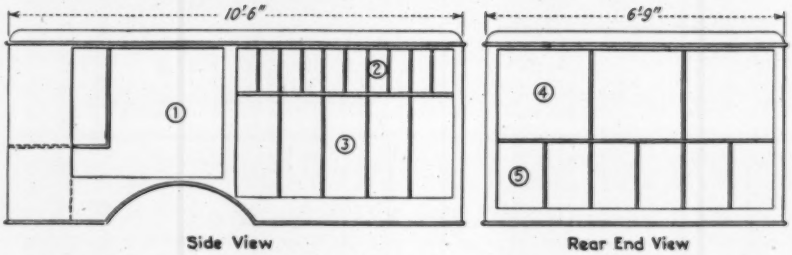
BRIGHT CLEAN SIGNS on the highway call for a regular check on condition and systematic removal for repair and repainting. To make sure of this servicing the engineering district of the Iowa state highway department, with which the writer is connected, puts all work of servicing signs in one department. The main tool of this department is the special truck illustrated which has proved its efficiency and economy.

The district has 1,578 miles of road to serve and the farthest county is about 167 miles from the paint shop. The sign truck is loaded with enough signs to last for one week of five days and it covers about 70 miles of roads in any county and returns and discharges the old signs to the paint shop in the week. In the one operation, the signs are checked, all needed changes made and the old signs returned to the paint shop for reconditioning with a maximum speed and a minimum handling; the work is not only thoroughly done, but it is uniform throughout the district.

The sign truck is started on the road as soon as the road conditions in the spring permit. Only one man is used and he is instructed to work all the roads in one county at a time, and in most of the counties he will complete the work in one week, and return and discharge his load of signs to the paint shop. He is required to inspect every sign on the road; to remove all not up to standard for appearance and service, and replace them with repainted signs; to note all irregularities in the placement of signs, and to replace any broken posts that may be on the roads.

The only tools that are necessary to attend to this service are two end wrenches, a punch, a hammer, a post hole digger, a tamping bar and a brace and ⅜-in. bit.





Sign servicing truck used in the Council Bluffs district of the Iowa highway department. Body of truck contains compartments giving ready access to any form and size of road sign in common use: (1) Compartment for signs to be repainted. (2) Compartments for small signs of less than a foot in width. (3) Compartments for 24-in. signs. (4) Compartments for refinished signs. (5) Compartments for road or route markers.

Foundation Unwatering Methods Used At Prado Dam

HOLDING DOWN the groundwater level was one of the problems in getting work started at Prado Dam, an earth-filled structure now being built in southern California for flood control purposes by the U. S. Engineer Department. The dam will have a crest length of 2,280 ft., a base width of 850 ft. and a maximum height of 105 ft. A central core of "selected, impervious rolled fill" constitutes the watertight portion of the structure, supported by flanking embankments of pervious materials with slopes ranging from 2½: 1 to 6: 1. (Previous references to Prado Dam appeared in *ENR*, June 23, 1938, p. 883 and Apr. 11, 1940, p. 500.)

Original plans called for a concrete cutoff wall along the axis of the dam. Because of high groundwater level and the resultant difficulty of excavating a trench to bedrock some 70 ft. below stream bed, the cutoff wall actually put in consists of a single row of steel sheetpiling driven to refusal on the sandstone underlying the gravels of the river channel. This row of sheetpiling, some 1,800 ft. long, terminates at both ends in concrete cutoff walls in the abutments.

Before driving the sheetpiling and in preparing to strip the entire area on which the embankment was to be placed, extensive pumping was carried on to lower groundwater as much as practicable. An opportunity for experimenting with pumping methods and equipment was afforded in unwatering a test pit 10x20 ft. in plan. This area was enclosed by steel sheetpiling driven some 70 ft. to bedrock and it was necessary to unwater it to determine the bearing values of the formation at different levels.

At first a pump was installed in a gravel-packed well adjacent to the test pit. The large percentage of fines in the sand and the numerous small clay lenses held down production in this well to about 700 gpm, which was inadequate. A complete system of wellpoints was then put in. This also proved inadequate for the same reason. Finally the test pit was unwatered by a vertical, multi-stage pump on a sling in a sump carried ahead of the pit excavation. At the same time, water level in adjacent area was held down by another pump of the same type hung on a tripod in a sump fed by ditches. Satisfactory performance of the vertical turbine pumps that unwatered the test pit resulted in adopting the same equipment for keeping down water levels over the entire area.

The second pump installation consisted of three units, (1) at the downstream toe near the abutment, (2) at the upstream toe near the opposite abutment and (3) on the axis near the river. At each of these locations a pump was slung on a tripod in a sump into which shallow ditches were led from the area to be dewatered. With these three pumps discharging about 15,000 gpm, the water table in the entire area to be covered by fill was drawn down about 2 ft. and held there while other pumps lowered the water level still further in areas where excavation or concreting was under way.

Typical view of Prado Dam site with water level held down by pumps.

Results of the work done in the test pit indicated that excavation preceding the placing of the rolled fill would have to be carried to about 30 ft. below river bed over one third of the area and 3 ft. below the river bed over the remaining two-thirds.

Progressively, as stripping operations were carried on over the dam site, ditches and sumps were lowered in 6-ft. steps until the water table was reduced and held at the necessary level during the placement of the fill. Groundwater was kept at least 10 ft. below the surface of embankment under construction. This was accomplished by using a perforated well casing around each turbine pump and adding to the length of the casing, in 2-ft. increments, as the fill was raised. When groundwater had been allowed to rise to its static level, and the completed fill was well above it, the well casings were filled with concrete.

A special unwatering problem was encountered in the concrete cutoff walls, 6 ft. wide, that were put down to bedrock to prevent undercutting at the lower end of the spillway. Here, in addition to up and downstream cutoff walls, web walls 38 ft. long were set on 30-ft. centers and carried down to bedrock. Trenches for these cutoff walls had to be heavily timbered to prevent caving and space was at a high premium. The turbine pumps, which required a minimum of space, were moved ahead in the trenches as the excavation progressed and were kept in operation until after the concrete had been poured. In this way it was possible to excavate and to place concrete in the dry.

Pump requirements on the job ranged all the way from intermittent operation against high head to constant, large discharge at low head. Solids in suspension ordinarily ranged from 7 to 10 per cent of the volume pumped and in some cases went as high as 25 per cent. With 16 pumps of 2 to 30-hp capacity only one man was required to look after them despite the fact that most of the pumping had to go on continuously day and night to hold water levels at the desired depth.

The contract for building Prado Dam is held by the Prado Constructors consisting of W. E. Callahan Construction Co., Guthrie-March-Peterson Co., J. P. Shirley and George W. Condon Co., all of Los Angeles. The pumps were supplied by the Pomona Pump Co.

Treatment for Delaware Water

***Contents in Brief**—Water from the new Delaware supply for New York City, like that from the existing Croton and Catskill systems, is of such good quality and so carefully safeguarded that filtration, while contemplated for the future, is not deemed necessary at this time. Safeguards include watershed sanitation, long storage, aeration, clarification with alum and lime when needed, multiple chlorination and continuous laboratory control now involving more than 30,000 analyses per year. See footnote for preceding articles in the series.*

WATER FOR NEW YORK CITY is not now filtered. Filters for the surface waters of the Croton and Catskill systems were designed many years ago but in view of the excellent quality of the water being consistently delivered without filtration these purification devices have not yet been built. The sanitary quality of the water is indicated by the daily analyses and by the low typhoid death rate. For the last five years the Catskill water, constituting about 60 per cent of the supply, has shown the following averages—turbidity, 2.2 ppm; bacteria at 37.5 deg. C., 6 per cc.; B. coli index, 0.3 per 100 cc. The typhoid death rate for New York has averaged 0.36 per 100,000, one of the lowest among the large American cities.

The city owns a site traversed by both the Catskill and Delaware aqueducts on which filters adequate for both supplies can be built when the need becomes evident. Meantime, the purity of the new Delaware supply will be assured by the same means which have proven effective for the Catskill and the Croton supplies. These are:

Watershed Sanitation—With the development of each new supply, the Board of Water Supply makes a detailed sanitary inspection of the entire watershed, removing sources of pollution in the vicinity of the streams and substituting suitably located watertight privies, chemical closets, properly designed and constructed domestic and institutional sewage disposal systems and appropriate treatment for offensive industrial wastes, if any.

Sewage Disposal for Villages—The Board constructs and the city maintains and operates, sewerage systems and treatment works for villages which, because of size or location, offer a sanitary hazard.

Watershed Inspection—The Department of Water Supply, Gas and Electricity, operating department of the city, maintains a continuous sanitary inspection of watersheds to prevent creation of new nuisances and the recurrence of old nuisances. Trained civil service inspectors traverse prescribed routes inspecting generally at least once a week all occupied or new premises adjacent to watercourses and not served by city-operated disposal systems, and guarding against pollution by hunters, fishermen and other visitors. Where new buildings are proposed the owners are advised in arranging for the safe disposal of wastes. Inspectors also investigate and report upon any case of typhoid or other possibly water-borne disease occurring on a watershed and, in cooperation with local health officers, the department sees that proper precautions are taken to prevent possible pollution.

Reservoir Storage—Reservoirs of the Delaware project will have an available capacity of about 232,000 million gallons and ordinarily will afford long periods of storage for sedimentation and bactericidal action. It is the policy of the operating department to maintain in the impounding reservoirs an emergency reserve of 25 per cent of the reservoir capacity to provide for contingencies. Therefore, except under extraordinary

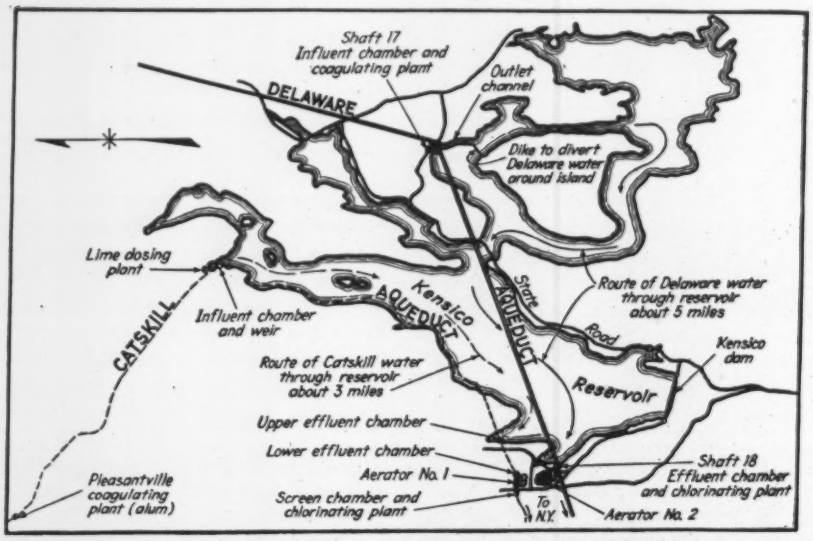


Fig. 1. Coagulation, chlorination and aeration facilities at Kensico reservoir. Delaware water will be coagulated, when necessary, the floc settling in the reservoir. Catskill water traverses 3 miles of reservoir before reaching the outlet, and Delaware water will travel 5 miles.

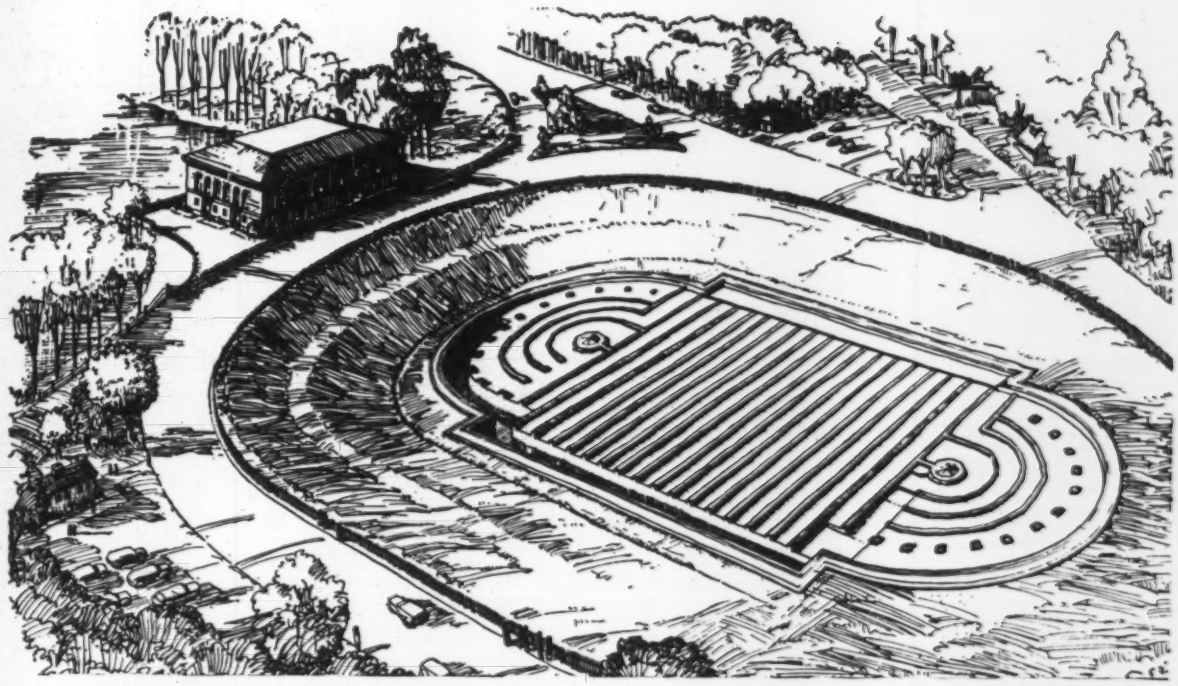


Fig. 2. Aerator for the Delaware supply will be a three-acre concrete paved basin. Provided with 3,492 spray nozzles producing fountains of varying form and height, it will aerate a maximum of 1,200 million gallons of water daily.

conditions, there will always be an ample detention period to effect a large bacterial reduction. Even when the storage reservoirs on the watersheds are depleted, the more than 30,000 mg of storage in Kensico reservoir near the city, which is always kept full, will afford a substantial detention for both Catskill and Delaware water.

Copper Sulphate Treatment—Taste and odor-producing microorganisms in reservoirs will be controlled by applications of copper sulphate. In addition, facilities are contemplated at the coagulating plant which will permit the continuous application of copper sulphate to the Delaware Aqueduct water entering Kensico reservoir whenever such treatment may be found desirable. For some years the water passing Muscoot Dam into Croton Lake, the largest and final reservoir of the Croton system, has been continuously treated with about 1½ lb. of copper sulphate per million gallons. This has provided 50 per cent reduction in the yearly average of total organisms reaching the city and substantially 100 per cent elimination of taste and odor-producing organisms.

Turbidity Removal—For the removal of occasional turbidity caused by storms on the watersheds, the Catskill water has been and the Delaware water will be coagulated, when necessary, with alum and lime before entering Kensico reservoir, where the floc will settle out. It is expected that the coarse turbidity will settle out in the storage reservoirs, only the very fine and colloidal matter reaching Kensico; thus silting in Kensico will be slow and confined to about the first mile from the intake.

Aeration—Catskill water is and the Delaware water will be aerated on leaving Kensico reservoir. This aeration increases the oxygen content when low, reduces carbon dioxide, removes musty tastes and odors, hydrogen sulfide and other objectionable gases, and destroys certain microorganisms.

Multiple Chlorination—Water of the Catskill supply is chlorinated three times, on leaving Ashokan, Kensico and Hill View reservoirs. The water of the Delaware system will be chlorinated four times, on leaving Rondout, West Branch, Kensico and Hill View reservoirs. This multiple chlorination permits effective sterilization, eliminates complaints of taste in the finished water, affords protection against any temporary underdosing, inhibits organic growths on the walls of the aqueducts, and tends to prevent the seeding of lower reservoirs with microorganisms from upper reservoirs as well as to eliminate the tastes and odors which they produce.

Laboratory Control—All of the above safeguards are under the continuous control of three laboratories, one on the Catskill watershed which will also control the Delaware watersheds, one on the Croton watershed, and one in Brooklyn. The latter maintains constant check on each of the many Long Island and Staten Island sources and on the water from all the sources of supply as it is delivered in the city. Over 31,000 analyses a year are now made and with the Delaware supply the number will be substantially increased.

Treatment facilities

Coagulating plants, aerators and chlorinating facilities for both Catskill and Delaware aqueducts are grouped around Kensico reservoir (Fig. 1). On the Catskill Aqueduct alum is automatically dry-fed, when required, directly into the grade aqueduct at Pleasantville, about 2 miles above the reservoir; lime is added for restoration of pH just before the water passes over a weir into a northwesterly arm of Kensico reservoir. From Delaware Aqueduct the water will enter the northeasterly part of the reservoir at shaft 17 where the Delaware coagulating plant will be located. Leaving Kensico, both aqueducts take

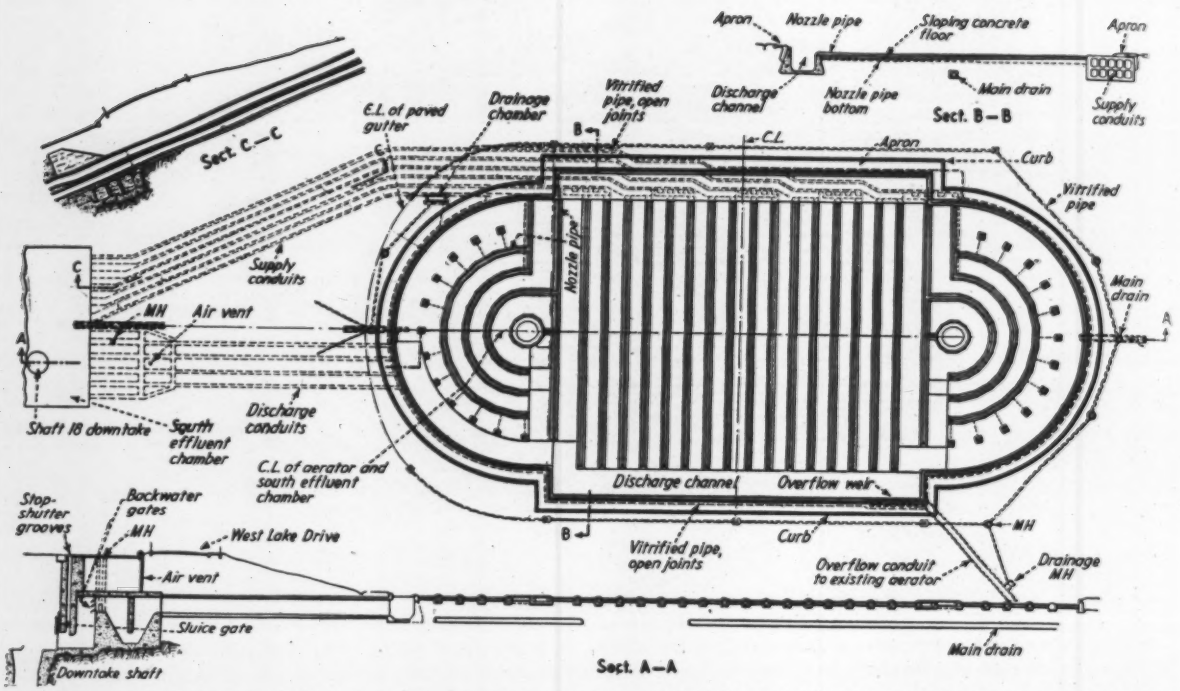


Fig. 3. Aerator design. Ten reinforced concrete supply conduits (upper left) conduct water from the Kensico south effluent chamber to 20 nozzle pipes in the aerator. After aeration the water is returned to the effluent chamber and downtake shaft of the tunnel leading to the city.

out from the southeasterly part of the reservoir through aerators, fine screens and chlorinating plants.

Delaware water rising through shaft 17 will enter the forebay of the influent gate house (Fig. 4) from which it can be sent either (a) through one set of gates into the downtake shaft to the bypass tunnel under the reservoir, or (b) through another set of gates directly into the reservoir, or, if both sets of gates are closed, (c) through the coagulating plant which forms part of the same structure.

In the latter case the water will flow first through a dosing conduit where the lime and alum will be successively applied, then through twin mixing channels, returning through a spillway channel and over a weir into the 1,500-ft.-long outlet channel (Fig. 1). This channel is formed in the reservoir by a dike of tunnel spoil laid parallel to the rectified shore line. Thorough mixing will be effected in the mixing channels where brief but violent agitation will be caused by the fall over the weir, followed by gentle agitation for 30 minutes or longer for the completion of flocculation by flow through the outlet channel.

Details of design have been worked out with the aid of extensive model tests (scale 1:12) with special reference to hydraulics, the completeness of mixing with and without either baffles or mechanical mixers, optimum dimensions, elevation of weir, etc. These tests led to the elimination of mechanical mixers, with their very considerable continuous expense for power, and the adoption of the system of baffles shown in Fig. 4. With these baffles the model tests indicated a good mixing of the lime before the introduction of the alum if the lime is applied at the primary lime dosing point, and highly satisfactory mixing of both lime and alum before the water reaches the spillway. The tests confirmed the details of design shown in Fig. 4 including a 136-ft. net length of weir at El. 361, giving a 5-ft. or greater fall into the reservoir.

Chemical mixing equipment

In the chemical house, about 57 by 76 ft. inside, which is above and astride of the mixing conduit and adjoins the gate house of the influent chamber, the facilities to be provided include:

On the operating floor—Space is provided for five gravimetric dry-feed machines for alum and three for lime, laboratory, office, and heating facilities. The alum machines will be in a row across the downstream end of the dosing conduit, the lime machines along the side over the spillway channel where the alum-treated and mixed water returns. Each dry-feed machine will discharge into a mechanically-stirred solution tank built into the floor and continuously supplied with water.

The alum solution and the lime suspension will spill over weirs into gutters, covered with removable gratings leading to the respective dosing points. The primary lime dosing point will be near the upstream end of the dosing conduit, the alum dosing point about 55 ft. farther downstream. An alternative lime dosing point near the downstream end of the weir will permit applying any desired proportion of the lime after the thorough mixing of the alum.

To facilitate the utilization of future developments in the art of water treatment the plant is being planned for maximum flexibility. In addition, it is proposed, after a period of experimental operation of the new plant, to consider the construction of a separate lime dosing plant at the discharge end of the outlet channel.

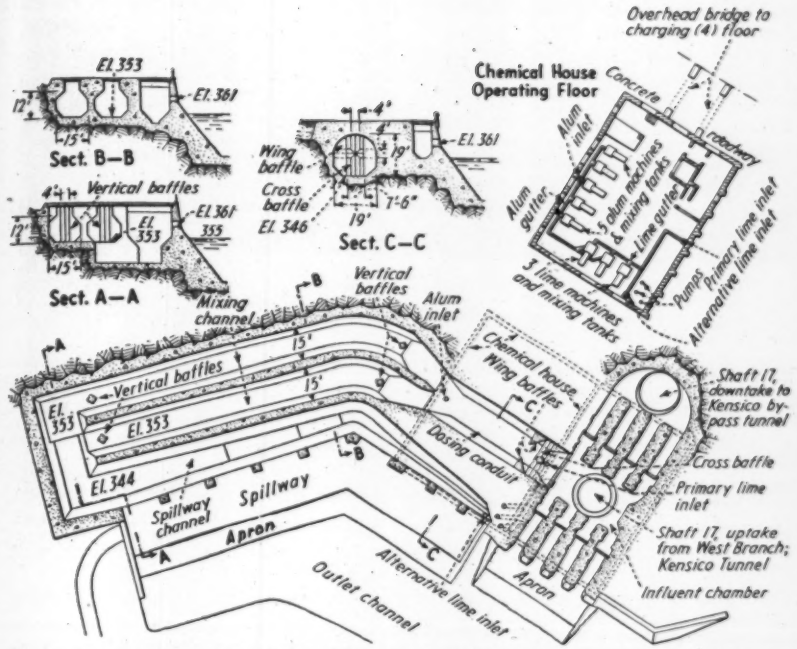


Fig. 4. Kensico east influent chamber and coagulation plant. At the influent chamber water can be sent directly into the reservoir, or through the bypass tunnel under the reservoir, or through the coagulation plant. In the latter lime and alum will be mixed with the water by a system of baffles and mixing channels.

Second and third floors—Here are the chemical storage bins, with hopper bottoms and gates over the dry-feed machines. For alum there will be 25 hoppers, 5 in a line over each alum machine, with a screw conveyor to transport the alum from any of the 5 hoppers in the machine. For lime, 3 bins with hopper bottoms, vibrators to prevent packing of the lime in the hoppers, and a screw conveyor, will supply the 3 dry-feed machines. Two of these bins and the corresponding dry-feed machines can be used for alum if desired.

On the top floor—Here is located a truck entrance by bridge from an adjacent high-level highway, storage space for chemicals in bags, water storage tank and an elevator. In very wet weather it may be undesirable to drive trucks onto the upper floor in which case chemicals in bags can be delivered onto warehouse trucks on the operating floor and taken up on the elevator. Two large exhaust fans drawing from the tops of the alum and the lime storage bins, respectively, will create such air velocities into the bins when the charging ports are open for dumping chemicals that no dust can escape to the charging floor. The dust will be collected in bag filters with automatic bag shakers and returned to the bins.

Supplementing hoppers and bins there will be storage space for chemicals in bags on all four floors. For an ultimate average draft of 640 mgd (540 from the Delaware and 100 from the Croton watershed) chemical requirements may exceed 90 tons a day, consisting of about 72 tons of filter alum and 18 tons of hydrated lime. The total chemical storage capacity in hoppers, bins and bags, will be about 1,200 tons.

Long travel in reservoir

After the violent agitation by spilling over the weir the treated water will flow, for further flocculation, through the outlet channel formed by the dike of the rock spoil extending to the large island in the reservoir (Fig. 1). For a flow of 640 mgd the mean velocity in the outlet channel will approximate 0.8 ft. per sec. The dike which directs the flow around the island, increases the length of travel through the reservoir by about 2½ miles. From the end of the outlet channel the length of the path through the reservoir will be about 5 miles compared with about 3 miles for Catskill water, and the anticipated time of transit of the order of 2 weeks. As this reservoir will always be kept substantially full to furnish an emergency reserve against shutdown of one of the aqueducts from the north, conditions in these respects should be stable.

Aerator design details

Kensico Aerator No. 2 which will treat Delaware Aqueduct water as it leaves Kensico reservoir will be a larger edition of the adjacent Kensico Aerator No. 1 which successfully has treated Catskill water since 1917. Differing in details of arrangement from No. 1, but identical in principle and similar in design of nozzle, it will have a capacity of 1,200 mgd. With the billowing masses of fine spray produced by 3,492 fountains of varying form, height and arrangement, and covering more than 2¾ acres, it promises to present an even more beautiful and impressive spectacle than Aerator No. 1. To accommodate expected visitors it will be surrounded by broad boulevards in a landscaped setting, with ample parking spaces and comfort station facilities (Fig. 2).

The aerator (Fig. 3) will consist of a shallow rectangular concrete basin with semicircular ends, surrounded by a 15-ft. sloping concrete apron to catch spray. The visible structure will be about 660 ft. long by 320 ft. wide and will cover an area of more than 4 acres. Sixteen lines of spray nozzles, the lines 19 ft. apart, will cross the body of the aerator; at each end a shorter transverse line of nozzles, and a central rosette of nozzles surrounded by four concentric semicircles of nozzles will afford variety in arrangement, form, height and spacing of sprays and jets. Nozzles in line will be generally 16 in. apart. An air lane on the long axis of the aerator, 14 ft. 8 in. wide between nozzles, will facilitate internal ventilation.

The nozzles will be supplied through welded steel supply pipes, concrete jacketed and portland-cement-mortar lined to from 5 ft. to 4 ft. diameter. Cast bronze nozzle bases riveted to the steel pipes will extend from the inside of the mortar lining to the top of the concrete jacket. To these bases the removable cast bronze nozzles will be bolted.

Water will be controlled by 10 sluice gates in the Kensico south effluent chamber on the shore of Kensico reservoir (left ends of Figs. 2 and 3). (See *ENR* July 18, 1940, p. 109.) Ten supply conduits each

approximating a 6x8 ft. rectangle will be built into a single 2-story reinforced concrete structure (Fig. 3). Two conduits will supply the special arrangements of nozzles at the ends of the aerator, each of the other conduits two of the transverse nozzle supply pipes.

The sprayed water falling onto the slightly sloping floor of the aerator will spill into an open discharge channel along one side of the aerator basin (the near side in Figs. 2 and 3). From this 23-ft.-wide open channel which will afford opportunity for the escape of entrained air, discharge conduits will return the water to Kensico south effluent chamber for chlorination and forwarding to the city.

Chlorination equipment

It is expected that the chlorinating equipment in the effluent chambers at Rondout, West Branch and Kensico reservoirs will include, in each case, a battery of 2,000-lb. per day vacuum feed chlorinators; chlorine will be piped from 1-ton chlorine cylinders on platform scales in an entirely separate chlorine storage room to evaporators in the chlorinator room, and then to the chlorinators.

In addition to the cylinders on the scales, storage space will be provided for about 27 full cylinders at Rondout, 18 at West Branch and 30 at Kensico, in addition to 15 empty cylinders (1 carload) at each chamber.

The strong and highly corrosive chlorine solution delivered by the chlorinators will be diluted with at least twice its volume of unchlorinated water, supplied by gravity from the reservoir or forebay, to reduce its corrosiveness to the piping and to the concrete linings of the aqueduct near the points of discharge. The diluted solution will discharge in each case at a point of considerable turbulence to encourage prompt dispersion and thorough mixing. For handling chlorine solutions, replaceable rubber-lined and rubber-covered steel pipe will be used throughout. Steam heat, thermostatically controlled, will be provided in chlorine storage and chlorinator rooms.

In view of the generally excellent character of the raw water, it is confidently believed that the precautions above outlined will for some years insure the high sanitary and physical quality of the delivered water. Meantime, the city is holding in reserve its Eastview filter site of 300 acres for the construction there of filters for both the Catskill and the Deleware waters when such facilities shall seem warranted.

This completes the series of articles outlining the design and construction features of the new Delaware supply. Material for the ten articles was reviewed, and a major portion written, by the Engineering Bureau of the New York City Board of Water Supply. We acknowledge with appreciation the special efforts made by chief engineer Charles N. Clark and designing engineer Leonard P. Wood. The series was inaugurated with the aid of the late Walter E. Spear, chief engineer of the board.

Other Articles in the Series

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Plant Protection Against Air Attack

LATEST OFFICIAL VIEWS on protection of manufacturing plants against air attack are briefed in a revised issue of "Minimum Requirements for Passive Defense Protection for Munitions Plants," prepared by the War Department. The suggestions cover selection of site, arrangement and construction of buildings; blackout provisions, protection against bombs, and concealment. In condensed form they are:

Site—Best site is in wooded and broken terrain, with structures located against hill slopes or in clearings.

Layout—Place buildings not less than 200 ft. apart, where possible, and avoid laying them out in straight lines or regular pattern.

Building Construction — Build powerhouses with solid exterior walls and roofs; other structures of daylightless construction if they can be operated without daylight illumination. Provide fire walls to localize interior fires.

Windows, where required, should be reduced to minimum area and placed as high as practicable above floor level (to reduce the chance of bomb splinter damage). Skylights should be avoided unless the design includes provision for their complete blackout in emergencies. Use wire glass or other shatterproof glass. Provide for future installation of exterior opaque shutters or curtains, preferably of steel and in any event secure against opening by air blast.

Vestibule all entrances, and shutter or curtain both inner and outer doors for blackouts. Make provision for emergency construction of barriers (concrete or sandbag) in front of entrances.

Place utility service lines below ground where possible, and provide for eventual duplicate water, gas and electric supply lines. A standby electric plant may be desirable.

Protect outdoor oil and gasoline supply tanks by placing them underground or in substantial vaults; protect outdoor transformers and oil switches.

Provide ventilation for 8-hr. blackout periods, and make sure that illumination is adequate for operation in such periods.

Fire Equipment—Place sand bins with shovels both inside and outside the buildings, in addition to sprinklers, fire extinguishers and other firefighting equipment.

Shelters and Protected Storage—Reserve space for shelters below ground, to be constructed in emergencies. They should be adequate for the entire working force, be proof against splinters and light bombs, be located outside of but adjacent to the parts of the buildings close to the working positions, and have entrances from inside. Build the structural parts of the entrances within the building at the time the plant is built.

Other Provisions—Provide an outdoor blackout circuit to permit of operating essential yard transportation. It should preclude upward beams and enable the necessary blue covers to be applied quickly. This circuit should be separate from the normal yard lighting circuit.

Arrange landscaping and planting for maximum concealment, and plan in advance for camouflage painting. If advice is desired on protective concealment, apply to the War Department.

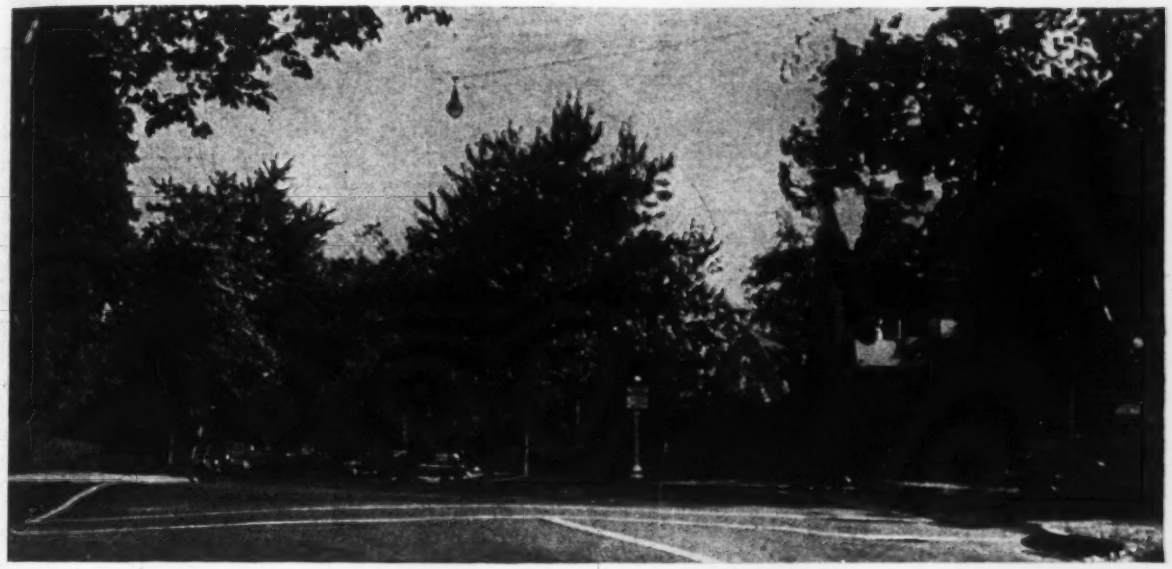


Fig. 1. New type refractor with only one lamp lights intersections as well as 100 ft. of each approaching street.

A Practical Lesson in Street Lighting

***Contents in Brief**—Good street lighting doesn't just happen—it must be designed, said Stuart M. Weaver, executive assistant to the commissioner of public works, Montclair, N. J., in a paper presented before the American Public Works Association on Oct. 1. The following extracts from this paper point to a number of practical recommendations adopted by Montclair for modernization of its system, which may have useful application elsewhere.*

HOW TO GET street lighting facilities which are three times as effective as an existing system at no increase in cost is being demonstrated in Montclair, N. J. This municipality, like so many others, was lighted by an obsolete, unplanned system, most of it over twenty years old. Aggressive action, which backed up the recommendations made by an independent consultant, inspired the local utility company to revise its conception of street lighting in accordance with Montclair's demands.

By following the principles laid down by the consultant, the utility is providing three times as effective lighting without increase of cost to the city. The utility must be given credit for expending at least $250,000 for a new lighting system, with no hope of increased revenue. It should be remembered, however, that utility rates provide for writing off lighting installations in from five to ten years. Consequently, the city has paid two or three times for the twenty-year old system it had been using.

Under a new five-year contract the company agreed to replace, within a year, the old system of 2,572 lights, ranging in size from 600 to 4,000 lumens (averaging 1,170 lumens), with a new system of 2,306 lights ranging in size from 1,000 to 6,000 lumens (averaging 2,260 lumens). All locations are being changed in accordance with carefully considered design and all brackets, luminaires and ornamental standards will be new. About half the system will be ornamental.

General plan and cost

The general plan prepared by Arthur J. Sweet, lighting consultant of New York City, provided for a complete new system of lights sup-

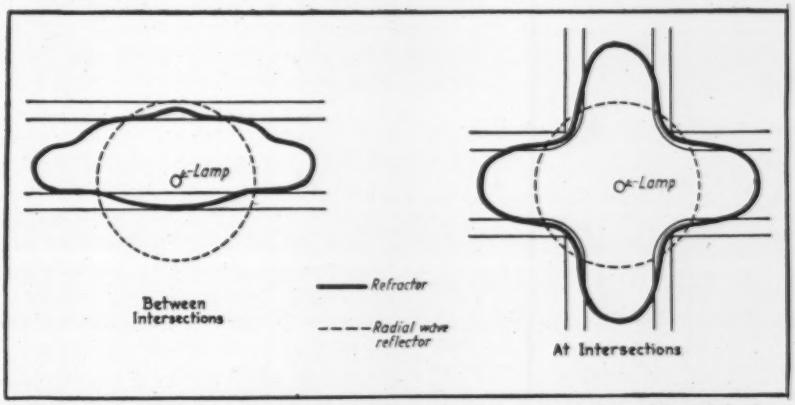


Fig. 2. Light distribution patterns of the refractors adopted by Montclair for better street lighting. The dotted pattern is that obtained from old-style reflectors which project a circular pattern on a limited area of usefulness.

ported on ornamental standards supplied by underground circuits. Ninety miles of streets are involved. No part of the old system was considered usable. The changes are conservatively estimated to provide three times as effective lighting as the old system. This is possible through (1) larger and fewer lights producing 65 per cent increased lumens; (2) refractors which put 2½ times as much of the light on the street; and (3) conservation of high intensity lighting for hazardous locations.

The consultant's cost estimate was based on a municipally owned and operated system. Such knowledge was of particular value in later negotiations with the utility which led to sweeping improvements. The estimated cost of a new city-owned system was $470,000; the annual operating cost, including write-off with interest in 20 years, was $60,500. This was based on utility supplied current at $0.0125 per kilowatt-hour. The utility, however, applied a $0.0174 rate and on this basis the annual cost would have been $65,625. Even this was $5,700 below the cost of the old, inferior lighting.

Armed with the consultant's plan of what the community could do for itself, the city was in a position to deal with the utility for substantially equal performance.

Design recommendations

The principal features of the engineering design of the new system were these:

Utilization of fewer and larger lights.

Adoption of higher mounting heights.

Employment of light controlling devices, such as refractors.

Adjustment of light intensities consistent with traffic hazards.

More light is the first step toward more effective lighting. And more light may be obtained for the same money with fewer and larger lamps. Inspection of utility rate schedules, for instance, shows that lamp outputs increase faster than the annual cost of operation; this is so because the major items of cost, capital and maintenance charges, vary little with size of lamps. Furthermore, facts are available to show that a 4,000-lumen lamp system will produce four times as much light per dollar as a 600-lumen lamp system. Similarly, a 2,500-lumen lamp system has a 3 to 1 advantage over the 600-lumen lamp, and 1,000-lumen lamps have a 1½ to 1 advantage over the 600 size.

Higher mounting height necessarily follows the wider spacing of fewer and larger lamps. High mounted lamps have two advantages: (1) they light more street length per lamp; and (2) they reduce glare. It has been found that light dropping at an angle of at least 1 ft. in 4 ft. enters the eye at a reasonably glareless angle. This limits spacing to eight times the mounting height—six is better. In Montclair a 25-ft. height was adopted for intersections, and a 20-ft. height was used between intersections; the presence of many shade trees prevented the use of a 25-ft. height throughout the system.

Value of refractors

Without refractors most of this efficiently generated light would be wasted. An ordinary bulb, either bare or surrounded by diffusing glassware and suspended under a reflector, directs less than 20 per cent of the light onto the street. The illumination pattern on the ground is circular, very brilliant in the center under the light, and rapidly diminishing radially.

Reflector-refractors, however, deliver over 50 per cent—2½ times as much of the light—onto the street. And instead of projecting a circular pattern onto the street and the immediately surrounding ground, they project an elongated elliptical pattern along the street. The lateral light, ordinarily wasted on private property or into trees, is redirected by the glass prisms and put to work on the street. Not only is the pattern elongated, but greatly intensified rays are directed toward the tips of the ellipse, to wipe out the dark spots ordinarily found between lights. This elongated distribution plus more efficient use of the generated light makes possible wide spacing with the economy of fewer and larger lamps.

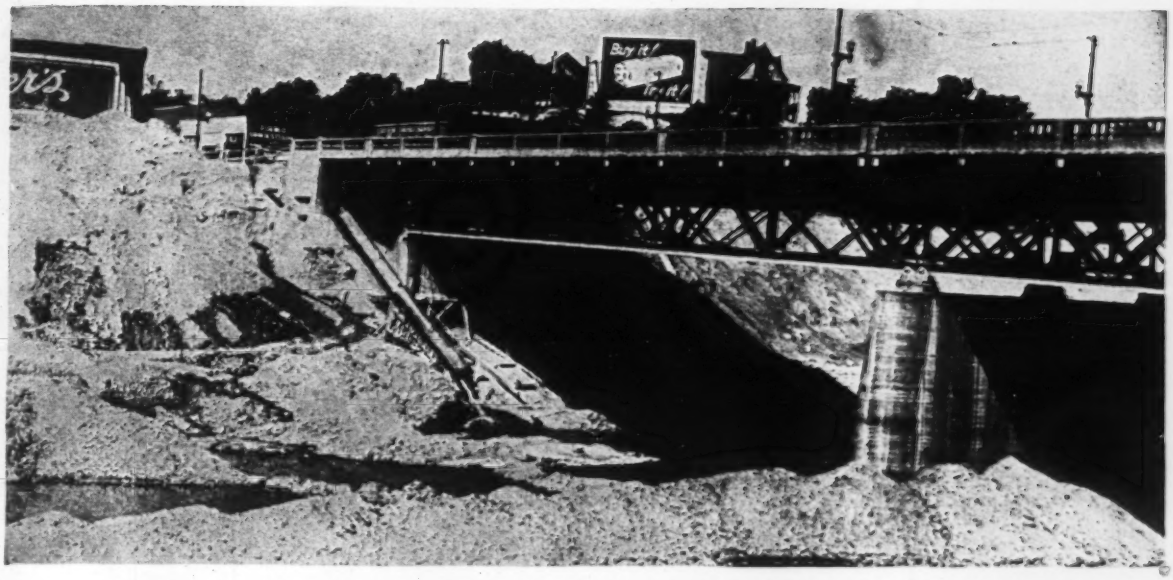
Street intersections, the scene of most accidents, and ordinarily expensive to illuminate, are effectively lighted by a four-way refractor newly designed for Montclair. Thus, one light suspended from a cable over the center of the intersection illuminates the intersection so that the pedestrian, cross traffic and street signs may be seen readily. And each of the four beams illuminates at least 100 ft. of approaching streets. Experiments demonstrated that the refractor bowl lighted nearly twice as much of the length of the approaching streets as did a diffuser bowl using the same bulb.

An economical lighting system, like an economical paving system, must be fitted to traffic needs. As unnecessarily wide and heavy pavements are avoided for purely residential construction, so unnecessarily brilliant lighting is also avoided. The saving so realized is used to step up the brilliance at intersections and on principal thoroughfares in proportion to their traffic density. Especially brilliant lights have been specified for suspension over intersections. This not only means better visibility and fewer accidents, but the prominence of the brilliant lighting will automatically warn the motorist of his approach to an intersection.

In conclusion, said Mr. Weaver, it should be pointed out that the engineering technique and acceptable equipment for good street lighting has been available for nearly twenty years. They have been applied in Milwaukee for nearly that long. Detroit and a few other cities have come to it more recently. The public demands governmental economy. It also demands traffic safety. Good street lighting can assist in satisfying both requirements.

Dust Storms Clog Sewage Plant Filter

As the efficiency of the trickling filters at the sewage treatment plant of Huron, S. D., was found to be far below normal, part of the stone was removed and disclosed that the filters were clogged with mud and dirt to a depth of 2 or 3 ft. The probable reason for this accumulation, as reported by Alfred Ross, superintendent of the plant, in *The Clarifier*, official bulletin of the South Dakota State Board of Health, was the dust storms of a few years ago, during a period of high winds and drought. At that time, the storms sometimes piled wind-borne material on the filters. By the use of high-pressure fire streams this foreign matter was flushed out, so that the efficiency of the filters gradually returned to nearly normal. In spite of the excessive amount of mud and dirt collected by the filters, there had been no unusual ponding on the filter beds.



Before draining and paving an unstable sliding bank endangered the Union Ave. Viaduct in Pueblo.

Bank Protection for New River Channel

S. F. Elliot
City Engineer, Pueblo, Colo.

Ross R. May
Engineer, Pueblo Conservancy District

***Contents in Brief**—When the meandering channel of the Arkansas River in Pueblo, Colo., was moved out of the industrial area across the flood plain alongside a sloughing bank, drainage and slope paving were necessary to effect stabilization. A viaduct abutment was endangered and a sewer line broken. The slope paving rests on a concrete toewall supported on rock.*

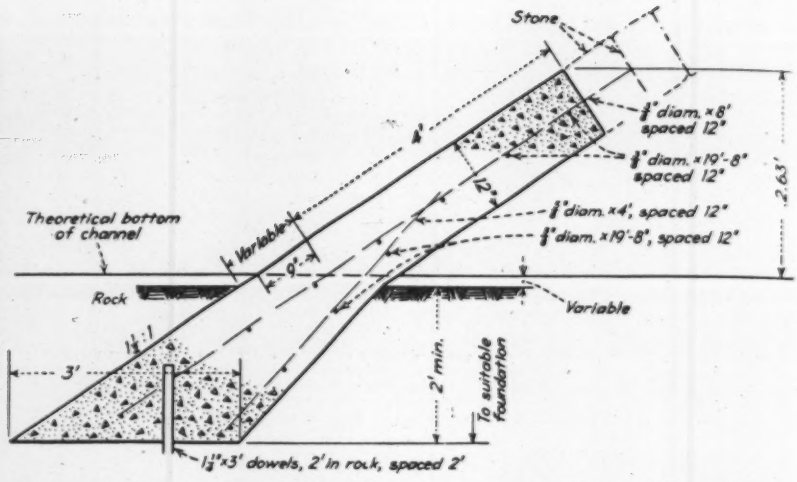
A SLIDING RIVER BANK in Pueblo, Colo., has been stabilized by drainage and by paving the slope with grouted rock, keyed in to the top of a concrete toewall founded on rock. Following the disastrous flood of 1921 and the formation of the Pueblo Conservancy District, a comprehensive flood protection plan was developed. It involved the construction at a cost of $4,000,000 of an entirely new channel for the Arkansas River which had meandered through the industrial section of the city. As reconstructed the channel was moved ½ mile south to follow the natural bluffs, thus providing one high bank. The opposite bank to the north is a new levee on the flood plain far enough away to give a 125,000-cfs channel, as compared with 40,000-cfs capacity before. The change in location required the erection of new bridges over the river and construction of viaducts over railroad yards.

The natural bluff, 45 to 60 ft. high, on the south side of the new channel consists principally of loose shale. Because of apparent stability and the limitation of funds this south bank of the river received no paving or other treatment at the time the original project was constructed. At some places, particularly in the vicinity of the South Union Ave. Viaduct, the south bank material was not shale, but earth and fill which had been placed in an arroyo to build up the original street.

At the time of the original construction and since that date the seepage water through this shale bluff, and especially in the fill material around the South Union Ave. Viaduct abutment, had caused continual slipping of the bank, with the result that one sewer line has been destroyed and restored four times. Finally, in 1939, the slipping of the bank caused the dislocation of the main Union Ave. sewer (an 8-in. welded joint line) to such an extent that the pipe broke in the river channel and one end moved downstream 10 ft., emptying the sewage directly into the river under the viaduct.

During recent years the city and conservancy district authorities were apprehensive of a major slip, which might conceivably throw enough earth and debris into the channel during the time of flood to cause overflow of the water over the north levee directly into part of the city's industrial and business district. Fears were also felt for the safety of the south abutment of the Union Ave. Viaduct which, although based on solid rock at a depth of 35 ft. from the bridge floor, had been weakened because of the unstable condition of the surrounding earth bank. These conditions led, in 1939, to the inception of a city-sponsored WPA project for the improvement of the south bank. Under a contract with the conservancy district the city sponsors the project while the conservancy district stands the entire cost of the

First lift of grouted riprap has been placed above the concrete toewall.



Details of concrete toewall at base of rock slope paving along Arkansas River.

sponsor's contribution to the work.

Plans call for the construction of drainage facilities to relieve the bad seepage condition, and for grouted rock slope paving of the entire south bank of the river, 300 ft. downstream and 1,050 ft. upstream from the Union Ave. Viaduct. The paving rests on a concrete toewall which is anchored into the solid rock under the river bottom. Other minor features include the relocation of the steel pipe intercepting sewer, concrete slope paving and reinforcing beams around the south abutment of the viaduct.

In the first phase of the construction, started in January, a drainage line was laid in the street at the top of the bluff. It was a 12-in. open tile drain packed in coarse gravel at a depth varying from 3½ to 23 ft. depending on the points where underflow and drainage were encountered. This drainage is carried from the main line through the slope paving into the river at two different places.

The next stage of construction was the building of the concrete toewall, started in March and completed in May. Construction of the toewall necessitated the location of a dragline in the river bottom to excavate the 1 to 4 ft. of loose material on top of the rock. This material was cast into the center of the river channel, the resulting dike forcing the normal flow of the river into the north half of the river channel. The toewall trench into the shale was dug by hand, with air drills and rock breakers.

Seepage developed in the shale for practically the entire length of the project. This was handled by placing weep pipes through the concrete toewall slabs as required. Excessive seepage was disclosed immediately east of the Union Ave. Viaduct and an excess of slide material at this point indicated the advisability of using a dragline for excavation. This was attempted in placing the dragline on the shelf, halfway up the slope, but after 4 hr. excavation of the lower half of the slope a serious settlement occurred, putting the dragline in a precarious position. The dragline was then removed and the large amount of soft wet muddy material was excavated entirely by hand.

Source of seepage

After the completion of the toewall in this section the dragline was placed on top of the bank and excavated the loose slide material to a depth of 15 ft. back of the slope line. This disclosed the principal source of excessive seepage water about halfway up the slope. It was then decided to place an additional drainage line in this section of the slope and, because of the previously unstable condition, a 6-in. spiral corrugated perforated metal pipe was used instead of tile. This pipe was placed in a trench parallel to the slope and covered with coarse gravel, with one branch of the pipe up the slope to the principal source of seepage and an outlet to reach the slope grade when finished. The perforated drainage line effectively dried up the seepage.

The next stage of the work consisted in placing the grouted rock slope paving. Sandstone rock, quarried about 6 miles from the project, was hauled to the site in trucks. The rock is quarried to a thickness of 12 in. and laid on the bedding plane of the stone. The first layer of rock is tied to the concrete toewall by means of the reinforcing rods left projecting 12 in. The rock is handled by sliding it down the slope on an improvised stone boat, pulled back to the top by a truck. Although crude, this method has proved effective.

A layer was laid from 10 to 20 ft. in slope width and 200 ft. in length before grouting. Grout was mixed on the top of the slope and poured through a chute to a distribution box near the upper edge of the completed section of the rock paving. From wheelbarrows it was dumped at the top and brushed down the slope into the crevices with stiff brooms. During the construction of the slope paving much additional seepage water developed at various elevations along the slope. Each spot was handled by placing a single weep pipe or an additional tile drain in a trench parallel to the slope. The prime purpose of this drainage is to relieve any back pressure behind the grouted slope pavement in addition to stabilizing the slope.

The Union Ave. Viaduct abutment was reinforced by placing three concrete beams as buttresses in front of the three casing type piers of the abutment. The beams were placed at the slope angle, which is 1½ to 1, and 12 in. below slope grade. In front of

the abutment reinforced concrete slope paving, 12 in. thick, was used instead of grouted rock.

The estimated cost of the project is $95,000. The total quantities used are 13,300 sq. yd. of rock slope paving, 1,412 lin.-ft. of concrete toewall, 23,000 lb. of reinforcing steel and 8,500 lin.-ft. of drainage lines.

The project, done entirely with WPA labor, was designed by Ross R. May, engineer for the Conservancy District, and Simon F. Elliot, city engineer of Pueblo. The construction was supervised by Mr. May.

Better Evaporation Data Sought

***Contents in Brief**—To furnish engineers more reliable figures on evaporation as a basis for planning hydraulic projects, the U. S. Weather Bureau is using one of Salt Lake City's water reservoirs as a field laboratory to try out a new method—the water-vapor transport method—of determining evaporation from readings of temperature, humidity and wind velocities.*

TO IMPROVE THE TECHNIQUE of measuring evaporation from water surfaces the U. S. Weather Bureau is experimenting in Morris Reservoir, Salt Lake City, with the water-vapor transport method of obtaining evaporation figures. Morris is a small regulating reservoir of the city's water system, concrete-lined, circular, 236 ft. in diameter at the surface, at El. 5200; it is continuously filled to capacity and thus provides an excellent, uniform exposure of water surface.

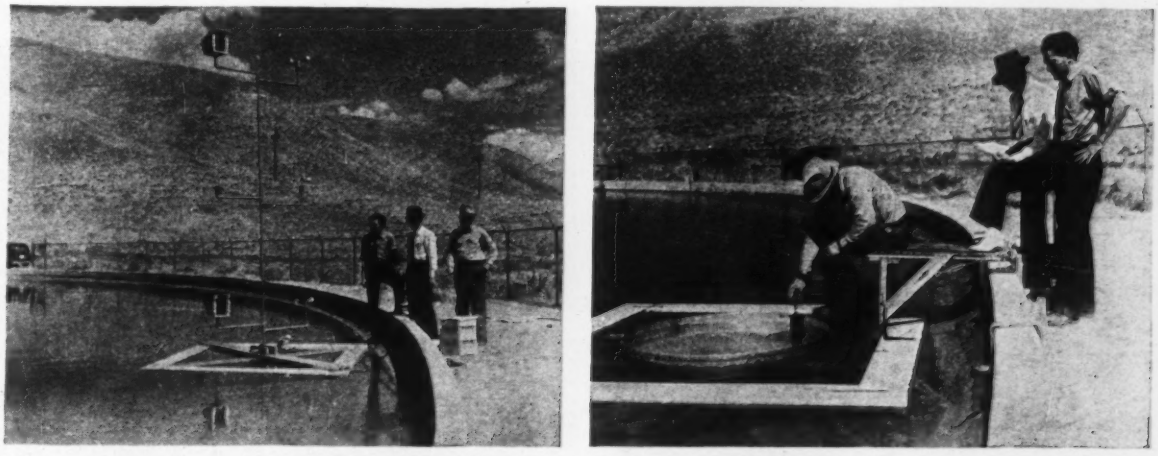
The bureau gathers evaporation data at 150 evaporation pan stations throughout the country. The loss from the open pans is presumed to indicate the loss from an open water surface, after a conversion factor is applied, but the pan is so artificial a device that the dependability of its evaporation data is questioned. A method is desired that will more accurately measure evaporation losses from water bodies of considerable extent.

The method being tried at Salt Lake City has been applied by Sverdrup in Europe and Montgomery in this country to evaporation from sea surfaces, and by Thornthwaite and Holzman to evaporation from land surfaces. This procedure, somewhat analogous to stream measurement, seeks to measure the actual flow of vapor upward from the evaporating surface. As water vapor is transported by atmospheric turbulence, its rate of flow depends on the vertical gradient of specific humidity and wind velocity (which determines turbulence).

Wind velocity is measured by anemometers at different levels above the water surface; humidity is measured at the same levels by electric psychrometers, and temperature and humidity at the water surface by hygrothermographs. A floating raft at the center of the reservoir carries a steel pipe frame which supports the anemometers and the psychrometer shelters. Check measurements for comparison and correlation are obtained from two floating standard pans (see right-hand view in illustration below) mounted on rafts placed in the reservoir itself, and from a standard land pan at the edge of the reservoir.

When the reservoir is available for such use, the final step in obtaining comparative data for study of the new method will be to bypass the reservoir and measure the evaporation from the reservoir itself by hook-gages placed in stillwells at various points around the circumference. The city water department has found the reservoir to be satisfactorily free from seepage loss, and good comparative results are therefore assured.

Preliminary data reveal that floating pan evaporation varies within a range of 30 to 40 per cent of that measured from the land pan, and that computations of evaporation from vapor transport data will approach the true values determined from changes in reservoir level.



Instrument raft in Morris Reservoir, Salt Lake City (left) carries electric recording anemometers and psychrometers at different heights. Evaporation calculated from the instrument readings will be checked against evaporation from standard pans (right) and against drop in reservoir level when inlet and outlet are closed.

Good Concrete Stays Good In New York Seawater

L. C. Hammond

Chief Engineer, Department of Borough Works
Manhattan, New York City

***Contents in Brief**—Survey of harbor structures at New York City reveals good concrete predominating. All disintegrated concrete can be traced to poor design or construction. Dense, rich mixes are required; protection is necessary within tidal range. Results of this survey were used as a guide in building the recently completed East River Drive structures.*

PRELIMINARY to preparing plans and specifications for the East River Drive in New York City, a study was made by the department of borough works of Manhattan to determine the suitability of concrete for seawater exposure and to determine the best concreting practices to secure the most permanent results for this exposure. Included in the study was the examination of 19 concrete structures in the Hudson, Harlem and East Rivers and in Jamaica Bay built between 1902 and 1932. At the time of the inspection, April, 1939, one structure was 37 yr. old, another 33 yr., two were 32 yr., five were from 20 to 30 yr., eight from 10 to 20 yr., one 8 yr. and one 7 yr. old. Inspections were made by ten members of the department, under the direction of the writer and L. H. Csanyi, assistant engineer. They were all made at low tide when the maximum area of the structures was exposed to view.

Some of the structures examined showed serious disintegration but in each case the effects could be attributed to violation of good construction or design practices. Some of the oldest structures have withstood the action better than some of the newer ones under identical conditions of exposure, the differences in performance usually being due to differences in construction practices. The investigation showed that concrete which can resist disintegration in seawater can be and has been secured in New York harbor. Dense concrete, ample coverage over the steel reinforcement, good workmanship and protection of the concrete in the tidal range with some form of facing to eliminate physical and mechanical damage, seem to constitute the necessary requirements.

Concrete used after studies

As a result of the investigation concrete was used in the East River Drive project. The materials were carefully selected; the concrete mix determined by trial to produce high density and strength; 6¼ bags of cement used in each yard of concrete; the sand was

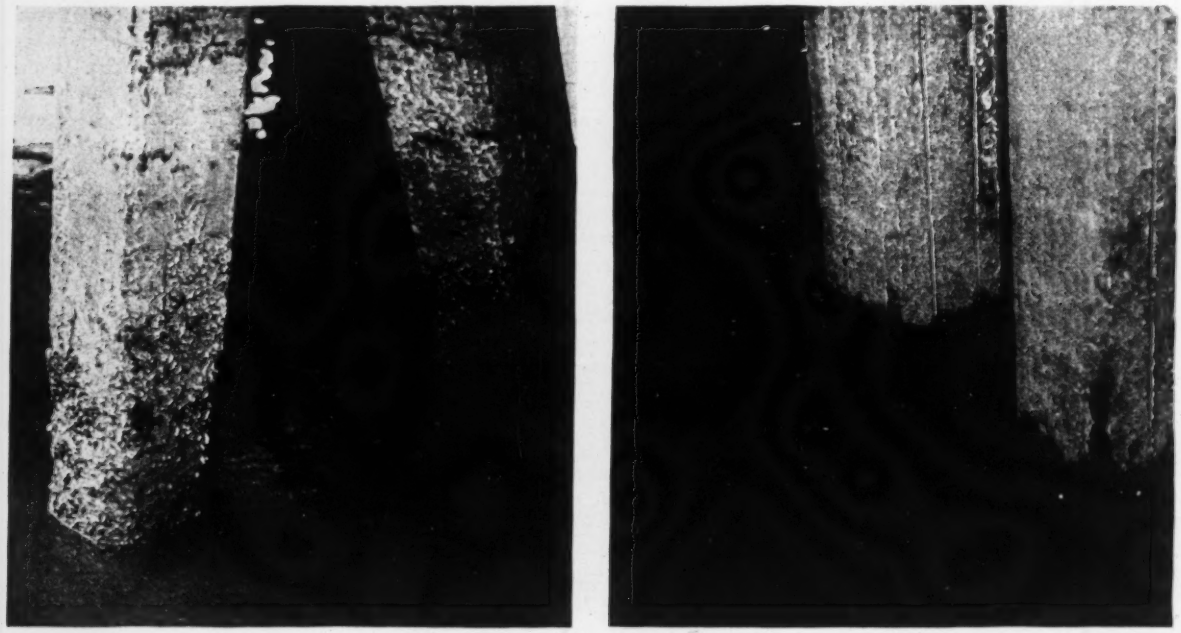


Fig. 1. After 10 years in Hudson River, piles at left are disintegrated while those at right are in perfect condition. Same specifications were used, but careless construction in one instance resulted in a porous concrete.

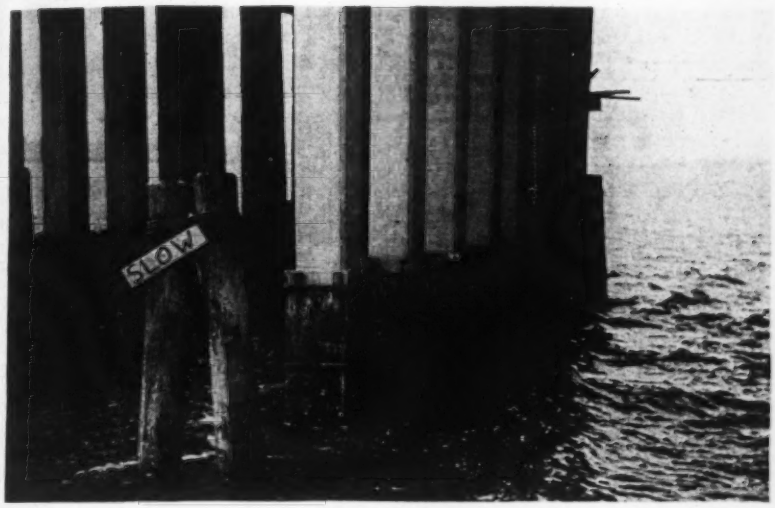


Fig. 2. Timber skirts in tidal range protect vulnerable part of piles in Jamaica Bay. Concrete is in excellent condition after 18 years.

well graded and required to contain from 3 to 7 per cent of fines passing a 100-mesh screen; all steel was covered with at least 2½ in. of concrete; strict inspection was maintained; bulkheads within the tidal range were protected with granite; and timber forms were in most cases retained on the undersides of slabs. As a further precaution against disintegration sulphate-resistant cement was used.

In the inspection of the harbor structures it was noted that on bulkheads there was characteristic disintegration at the bottom of the masonry walls where the concrete rested on the timber cribbing. It is believed that this was caused by the use of leaky forms and mixes that permitted accumulation of coarse aggregates at these locations. It was noted that, contrary to general opinion, disintegration above the high water line was not very prevalent and not nearly as severe as had been anticipated, even in cases where heavy wave action occurred or where the concrete was of relatively poor quality. The injurious effects of abrasion from floating debris and ice and the battering of docking vessels were frequently apparent and indicated the need for some form of protection, either wood or masonry facings within the tidal range and on outside faces of docks. Where decks had been subjected to alternate wetting and drying by wave action they exhibited good resistance when not subjected to prolonged wetting and consequent absorption of water, as in tidal action.

While it was difficult to examine the submerged concrete in most instances, the waters in Jamaica Bay and portions of the East River were clear enough to permit visual inspection for some distance below the water line on a few of the structures. It was found that very little disintegration occurred below low water, even where the concrete was of such poor quality that severe disintegration had taken place within the tidal range.

Performance of precast piles

The contrasting performance of precast piles on the 46th St. and 107th St. piers in the East River (Fig. 1) shows the need for exceptional care in workmanship on such relatively thin sections containing considerable reinforcement. On both structures the piles are 14 in. square; they are 62 to 74 ft. long on the 46th St. pier, and 55 to 65 ft. on the 107th St. pier. The same specifications were used on both structures. The 46th St. pier was started in October, 1931, the 107th St. pier in January, 1932. Piles on the 46th St. pier show considerable disintegration within the tidal range and the concrete appears very porous. On the other hand, the piles in the 107th St. pier are in excellent condition, the surfaces still showing the marks of the rough form lumber. It is of interest to note that surface scaling had started on the piles of the 46th St. structure when an examination was made in 1935, only 3 yr. after the piles were placed.

Among the structures examined was the Jamaica Bay Causeway, construction of which began in January, 1922. The total length of the structure is 23,505 ft., of which 8,785 ft. is of reinforced concrete pile and deck construction. The deck consists of a 36-ft. roadway with 16 ft. of sidewalk, supported on some 2,200 piles 24 in. square in bents spaced on 24-ft. centers with expansion joints every 72 ft. The height of decking above mean high water varies from 9 to 31 ft. Specifications required sulphate-resistant cement, 3,000-lb. concrete at 28 days, continuous wet curing for at least 60 days before driving piles and a coat of bituminous paint applied, before driving, to the portion of the pile situated between 2 ft. below low water and 3 ft. above high water. After driving, this portion was further protected by a creosoted timber sheeting strapped around the pile.

Examination of the piles showed that all of them were in excellent condition. At one or two places where the timber protective sheeting had fallen away, due to corrosion of the metal straps, the concrete within the tidal range was examined. Here, also, the concrete was in excellent condition, showing no signs of disintegration. The care used in its construction and the precautions taken to protect vulnerable spots, are paying good dividends on the 17-yr.-old structure. While sulphate-resisting cement was used on this project, so far as is known normal portland cement was used on all other structures examined.

The bulkhead wall from 77th to 78th Sts. in the East River is constructed of large granite blocks set upon rock. The surface of the rock was very irregular and in order to level it, concrete in bags was placed on the surface and the granite blocks were then set on the cushion of bagged concrete. Examination of this wall disclosed that the concrete is in excellent condition and so dense and tough that a piece could not be dislodged from an overhanging section with a five-pound sledge hammer and heavy chisel. While the mixture used was leaner than would be generally used for seawater exposure today, very likely it has a low water-cement ratio since stiff concrete is usually required for placing in bags. The con-

crete had been in place for 32 yr. at the time of inspection, and there was every indication that it would serve its purpose indefinitely.

A bascule bridge over the Dutch Kills was built by the Long Island Railroad in 1909. There are four plain concrete footings about 5 ft. in diameter under the fulcrum of the span. These were protected by 6x2-inch timber sheeting extending from the bottom of the creek to within 6 in. of the top of the footing. The tops of these footings are only a few inches above high water. Inspection of one of these footings from which the sheeting had been removed showed that while there were indications of some disintegration on the surface, the concrete is in excellent condition. Considering the age of the concrete and the characteristics of the water to which it has been subjected, its resistance to disintegration has been exceptionally good. Newtown Creek, to which Dutch Kills is a tributary, is practically an open sewer, carrying not only domestic sewage but also high concentrations of industrial wastes. The water is highly acid. Such conditions are highly corrosive to concrete, yet the concrete, protected by only a timber sheeting, has stood up exceptionally well for over 30 years.

Precast bulkhead blocks

A bulkhead consisting of precast blocks, each containing 7 cu. yd. of concrete, was constructed at 207th St. in the Harlem River in 1927. A well designed mix containing 5 gal. of water per sack of cement and giving 2-in. slump concrete was used. The concrete is in excellent condition after 12 yr. of exposure. There are no signs that can be discovered of incipient disintegration at the joints between the blocks.

The investigation proved that, in spite of the severe disintegration noted in some of the structures, concrete can and does resist the ravages of seawater over long periods of time when it is properly designed, mixed, placed, cured and subsequently protected.

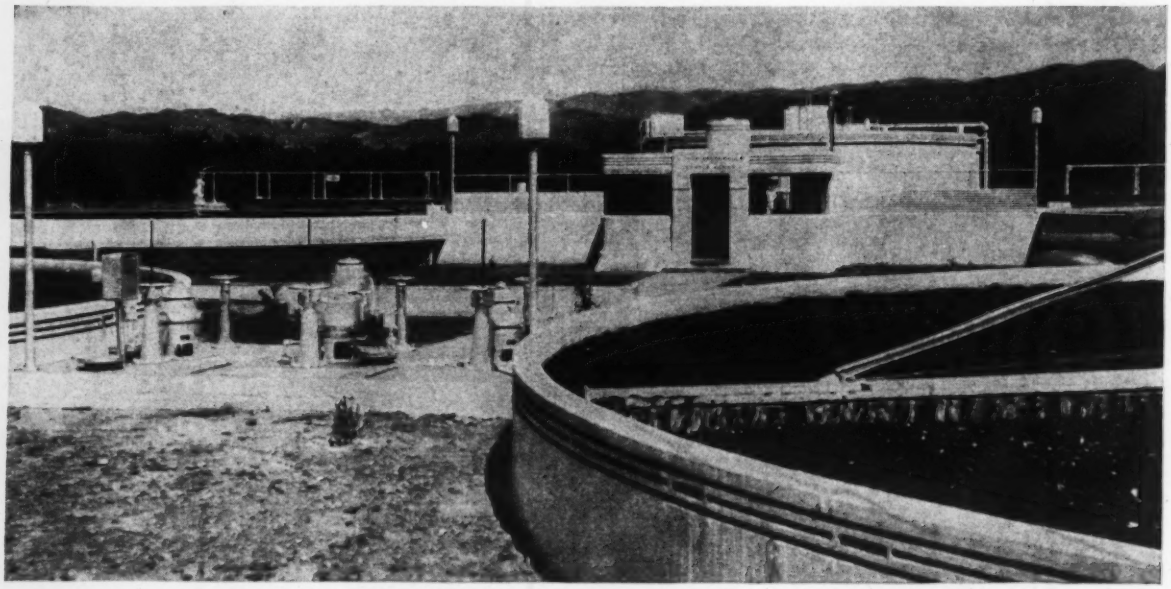
It is felt that with the precautions taken in the construction of the East River Drive there is every assurance that a structure has been built that will meet the requirements of its severe exposure.

Biofiltration Effluent Used For Irrigation at Santa Paula

EFFLUENT from a biofiltration sewage treatment plant serving 12,000 people in Santa Paula, Calif., is used to irrigate orchard lands adjacent to that city. A close-up of the biofilter bed, with the control house between the detention-settling tanks in the background, is shown in the accompanying illustration.

The low head propeller-type primary and secondary recirculation pumping units are seen between the biofilter structures. Combined with the ornamental strips around the filter walls may be observed the rectangular ports communicating with the underdrain grillage. This arrangement is said to insure natural ventilation of the 3-ft. depth of filter rock in each bed and thus assist aerobic action of the organisms in the purification process.

Proud of its fine-looking and useful treatment plant, the city held open house at the sewage disposal works to celebrate the completion of the first year's operation. F. G. Bennett, city engineer and associate designer of the plant with Harry N. Jenks, consulting engineer, Palo Alto, believe this is the first time that a disposal works has been made the object of a birthday party.



Functional in design and application, this treatment plant converts sewage into irrigation water.

Depth of Frost Under Pavement

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New Jersey College for Women,
New Brunswick, N. J.

MEASUREMENTS of the depth of frost under concrete pavement made by the writer on pavement in front of the Physics Building of the New Jersey College for Women at New Brunswick offer roadbuilders some interesting information. The tests may be defined as determining the temperature gradient of a concrete road.

Just before the concrete was poured at the place selected for the observations a ½-in. gas pipe was laid flush with the subgrade surface and extending from the center of a concrete slab to the side of the road beyond the curb, where it was bent up to the surface of the ground. Both ends of the pipe were capped. The concrete placed over this pipe was 9 in. thick, by proportion, 1:1.71:3.5.

The temperature at the bottom of the concrete slab was measured by placing one junction of a copper-constantan thermocouple inside the gas pipe, which contained alcohol in the lower part, and the other junction in a thermos bottle containing a mixture of ice and water. The temperature was read on a sensitive portable galvanometer, which was calibrated to read in Fehrenheit degrees. A mercury thermometer reading in the same scale was laid on top of the concrete to indicate the temperature of the upper surface. This thermometer was shaded when the sun was shining. The temperature of the air was measured by a continuous recording thermometer. As the water pipes were located 6 ft. below the surface of the ground, the minimum temperature of flowing tap water gave some indication of the temperature at that depth.

The data used were taken during four weeks when the weekly average temperature of the air decreased. Its minimum temperature for a few hours one morning was —10 deg. F. It required about 24 hr. for the effect of a sudden drop in the temperature of the air, to register a corresponding lowering of temperature on the under side of the concrete.

Fig. 1 shows the variation in temperatures for the sixth week of the experiment. Fig. 2 gives the results using average temperatures, plotted from the values given in the accompanying table. Under the numerals 3, 4, 5 and 6 are shown the averages for these weeks. Under the Roman numerals are shown averages for other periods of time which give intermediate points.

An examination of these temperature-gradient lines shows that there is a point 7 ft. below the upper surface of the concrete where the temperature remains about constant at 45 deg. The freezing line, 32 deg. F., crosses the minimum temperature line at nearly 5 ft. below the upper surface of the concrete. However, these low temperatures were of short duration; probably the frozen soil did not extend below 4 ft. If the temperature gradient line, *A B III*, in the concrete, is extended to meet the frost line, this point, *B*, is 16.5 in. below the upper surface of the concrete, which shows that frost might just pass through concrete 16.5 in. thick, which is nearly double the actual thickness.

The tests were made at the suggestion of C. A. Stelle, inspector, New Jersey state highway department, who placed the pipe for the test.

OBSERVED TEMPERATURES AND DEPTHS OF FROST IN PAVEMENT TEST FOR FROST PENETRATION

(Readings are in Fahrenheit degrees)

No. of Period	4	3	VI	5	V	6	IV	III	II	Min.
Above pavement	35.1	31.1	24.4	16.8	15.6	12.5	9.5	2.9	−0.9	−10.0
Below pavement	36.2	34.4	30.6	29.1	26.0	22.4	20.2	19.0	14.6	11.0
Tap water	....	....	43.0	41.5	40.0	40.0	40.0	40.0	39.0	38.0
Period in hours	168	172	10	168	86	168	64	64	34	....
Depth of freezing, ft.-in.	....	3 in.	1 ft.	1 ft. 9 in.	3 ft.	3 ft. 8 in.	4 ft. 2 in.	4 ft. 2 in.	4 ft. 7 in.	4 ft. 10 in.

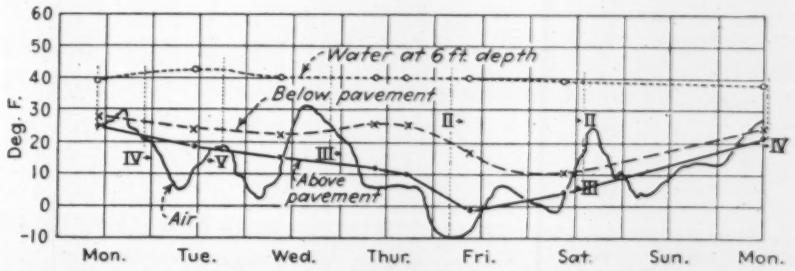

Fig. 1. Record of temperature readings during sixth week of observations on penetration of frost below a 9-in. concrete pavement. Roman numerals indicate various periods of observation.

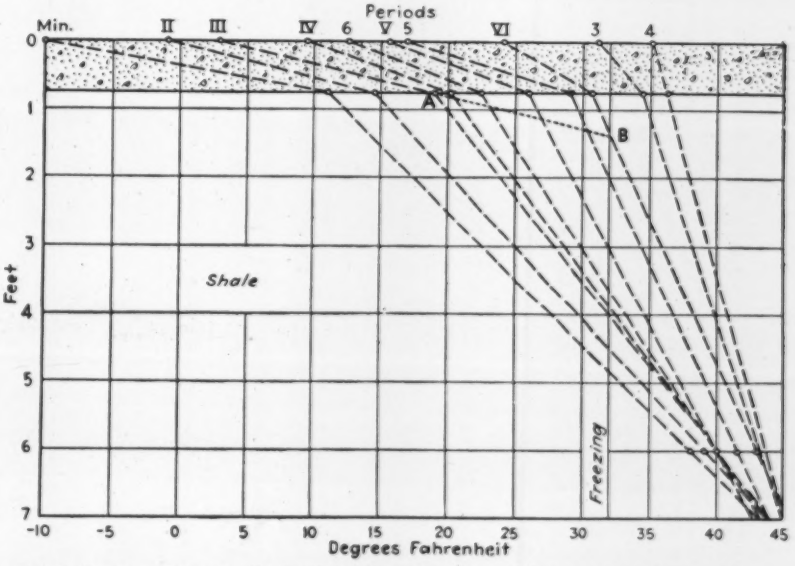

Fig. 2. Temperature gradients through and under a 9-in. concrete pavement.

Supporting a Hillside During Reconstruction of Old Retaining Wall

H. S. Ayres
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***Contents in Brief**—A cracked and leaning retaining wall 35 ft. high, supporting a hillside street in Pittsburgh, was reconstructed without disturbing the street by building individual counterfort walls in sheeted pits and using them to support the earth of the hillside by walls and sheeting while taking down the old wall and building a reinforced-concrete slab wall tied to the counterforts and faced with the old stone.*

AN OLD STONE RETAINING WALL along Itin St. in Pittsburgh, built more than 50 years ago to retain a steep hillside and a hillside street, has long been badly cracked and in need of reconstruction. Recently it was found to be leaning out as much as 30 in. at the point of maximum height, where it extended about 35 ft. above the pavement of Itin St. below, and evidently was in such bad condition as to require immediate replacement. Reconstruction has been successfully completed at a total cost of about $53,500 for the 80-ft. length rebuilt, using the novel expedient of building counterforts in individual sheeted pits some distance back of the old wall, and subsequently building a new stone-faced reinforced-concrete wall in front of these counterforts and anchored to them, under protection of sheeting supported by the counterforts. The three views herewith show the original wall and the counterfort and face-wall anchorage system.

The problem

The problem was to reconstruct the old wall without endangering the leaning wall or letting down any part of the upper street. No construction plans of the wall were available, and as test borings indicated an unaccountable variation in its thickness the strength of the wall could not be determined. Its condition left no doubt that the most dangerous section must be replaced without delay, but available funds limited the length of section to be rebuilt at present to about 80 ft. After some study of the problem a method that was believed to be safe and satisfactory was developed by the bureau of engineering of the city public works department. The work was carried out in accordance with this method by contract as a PWA project.

When a 60-ft. length of the wall had been reconstructed the adjoining section was found to be in almost equally bad condition. Accordingly, an additional 20-ft. length was rebuilt, this time under regular city

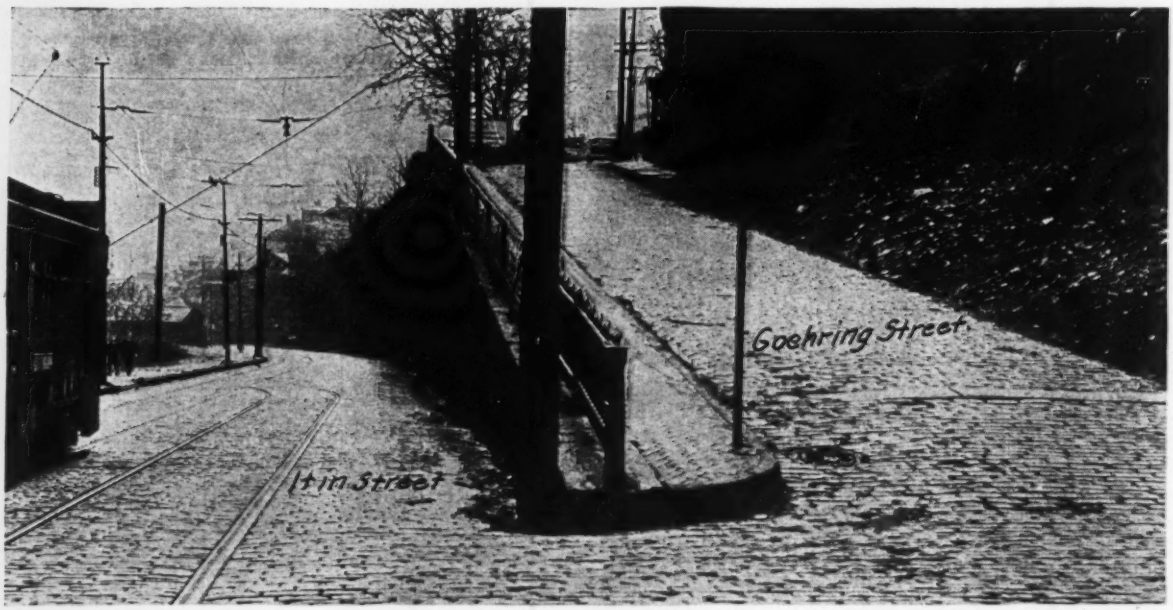

Fig. 1. Itin St. wall was badly cracked and leaned outward as much as 30 in. in its height of 35 ft. The most dangerous part of the wall has just been replaced without disturbing the hillside street above.

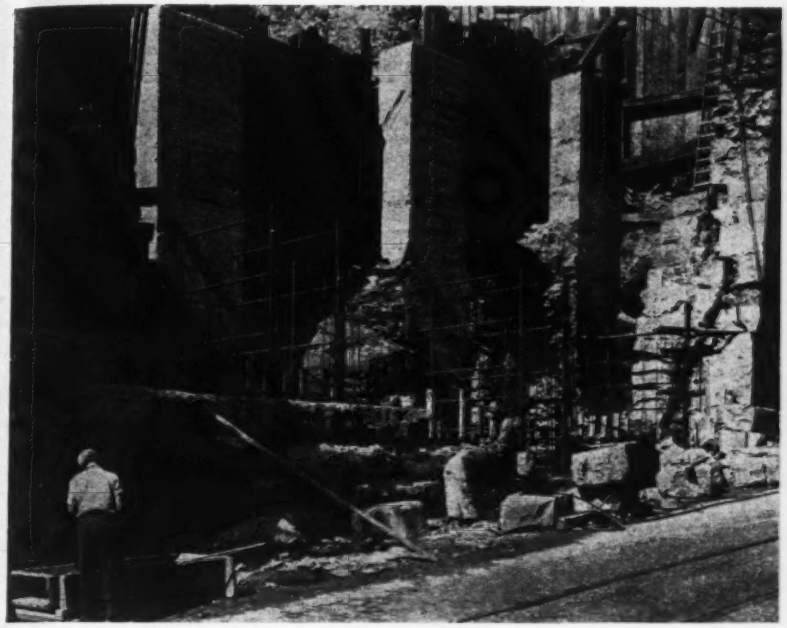

Fig. 2. Outer ends of four counterforts, supporting wales and sheeting to retain the hillside. Tierods 2 in. in diameter will anchor a reinforced-concrete wall slab to the counterfort; the stone of the old wall is laid up as facing and outer form of the slab. The wide crack between upper and lower parts of the old stone wall, at the right, is typical for the entire section of wall reconstructed.

Fig. 3. The final 20-ft. section of reconstructed wall includes special anchorage for the abutting end of the old wall. Construction of the face slab in the 20-ft. closing section remains.

contract. Fig. 2 shows at the right the condition of the masonry in this 20-ft. section, which is typical of the condition of the entire length of rebuilt wall. The defective bond, reduction of thickness and failure of the wall by diagonal shear apparent here are responsible for the conditions which made it necessary to undertake the reconstruction operations. Fig. 3 shows the special anchorage provided to tie the present end of the masonry to the last of the new counterforts, just before constructing the face slab of the 20-ft. section.

The plan of reconstruction involved building I-shaped concrete counterforts 20 ft. apart, far enough back of the wall to clear the masonry, each in its individual pit. During excavation of these pits great care was taken to carry all thrust from the sheeting to the bottom of the excavation by diagonal bracing timbers and to avoid placing any additional load against the wall. The rear flange of each counterfort provides the necessary weight against overturning, and the front flange provides bearing area as well as lateral support for the temporary wales which in turn support sheeting placed to retain the hillside during the rebuilding of the face wall. After completion of the entire work, moreover, the weight of the backfill adds to the stability of the wall by friction against the sides of the counterforts.

The stone from the old wall was redressed and used as facing and outer forms for the new wall, a reinforced-concrete slab wall back of the stone facing, designed to resist the full earth pressure. The slab is anchored to the counterforts by 2-in. round rods spaced 18 in. to 4 ft. vertically. As will be seen, all permanent steel is encased in concrete and the entire thrust is resisted by the counterforts.

The arrangement of counterforts, face wall and anchorage is indicated by the drawing Fig. 4. The counterforts, which are heavily reinforced, are 6 ft. thick at the heads and 3 ft. thick in the middle or web sections, 17 ft. wide (at right angles to the face of the wall) in the body and 21 ft. at the base. They rest on shale or harder rock of the hillside strata.

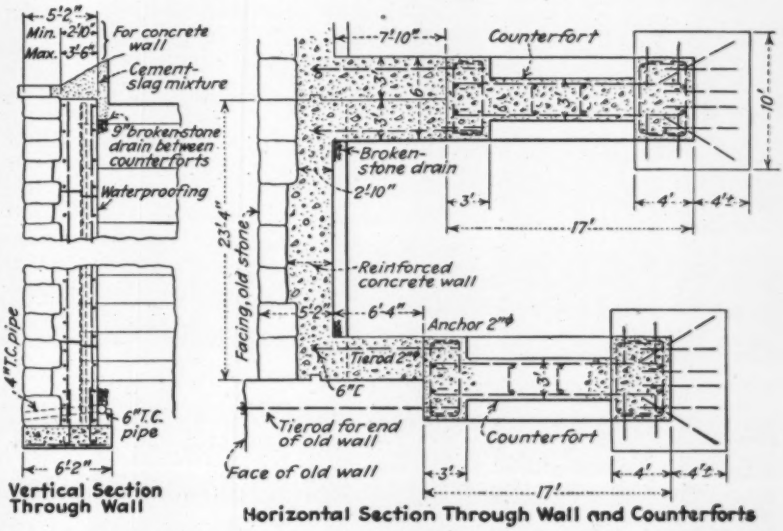

Fig. 4. Counterforts and new face wall; reconstruction of 11th St. wall, Pittsburgh.

Precast Box Beams for High Strength

Homer M. Hadley
Regional Structural Engineer, Portland Cement Association, Seattle, Wash.

TO DETERMINE the load-carrying ability of a new type of deck member for short span bridges, a precast cellular concrete beam of full size was tested last summer at the plant of the Diamond Cement Co., Seattle, Wash., in the presence of some sixty engineers. Since, under severe loading conditions, the beam performed in a very satisfactory manner the results of the test may be of interest.

The beam was characterized by sections of minimum size: 3-in. top slab, 1½-in. bottom slab, 2 and 3-in. longitudinal webs and 2½-in. cross webs. To save weight and to reduce cost, all unnecessary material was eliminated. On the other hand relatively large fillets made the unbraced length of the thin sections not greater than 6 in. either horizontally or vertically, while the transverse diaphragms so braced, stiffened, and interconnected all parts that an extremely strong and rigid combination resulted. "Bundle-bars," each consisting of four ½-in.-sq. bars separated by ¼-in. spreaders and wired tightly together into a single bundle, constituted the principal reinforcing as shown in Fig. 2.

Beams to form solid deck

It is contemplated that a number of these beams would be placed closely side by side spanning between common supports, thereby constituting the bridge deck. Because standard specifications assume a 3-ft. spacing between the wheels of adjoining trucks, that dimension was taken for the beam breadth, since it is thereby impossible logically to assume more than one full wheel on a given beam. As contrasted with most bridge deck slabs, which carry their wheel loads to supports by bending, it is the distinctive characteristic of this beam that loads between the longitudinal webs are carried principally by shear; with the short 6-in. lengths of the thin top slabs and the heavy fillets, no very considerable local bending stress can develop in them, since the wide tires of trucks bring at least part of the load directly over a web.

The test beam, for a 19½-ft. span, was designed for a standard H-15 rear wheel of 12,000 lb. and for 3,500 lb. impact—a total of 15,600 lb. It contained 45.5 cu.ft. of concrete, weighed about 7,300 lb. The concrete contained 8 sacks of high-early-strength cement and 5¾ gal. of water per sack. It was 15 days old when tested.

No testing machine being readily available that could accommodate its 3-ft. breadth, loads were applied by means of two 40-ton jacks, with dial gages, reacting through some intermediate framing against the upper portion of the dust-collector building at the cement mill.

Loading method

In the loading set-up a pair of 14x14-in. timbers, leveled and bedded in sand, formed a base upon which two pieces of heavy I-beam acted as supports for the concrete beam. By shifting the I-beams, tests could be performed on various spans. The loading jacks were applied at the center of the beam through plates 3 in. wide and 9 in. long, without plaster of Paris or other bedding. In the first three loadings, the 9-in. length of plate was turned transversely to the span; in the fourth it was turned parallel.

The applied loads and the induced stresses are shown in the accompanying table. Of primary interest of course was what load the beam could support on its normal full length span. Since it was not possible to develop shears of any magnitude in the webs on the full span, it was also loaded on shorter spans, and shears up to 860 lb. per sq.in. were registered.

The stresses in the table are based on a *jd* of 13.5 in. and compressive stresses are assumed to act only on the top 3-in. slab and uniformly from its top to bottom. The first load, 46,800 lb., was applied eccentrically, with one jack only, 9¾ in. from the side of the beam. No appreciable effects resulted from the eccentricity. The typical fine hair cracks which developed were about equal on both

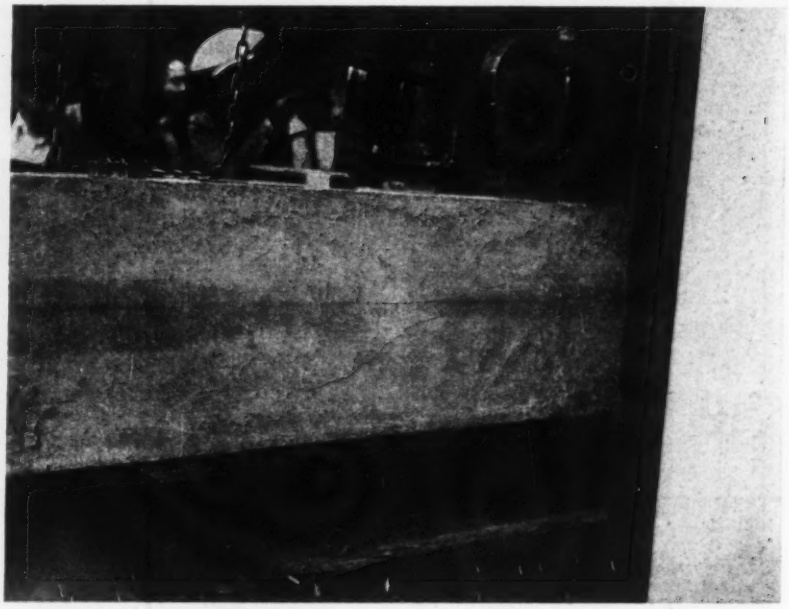

Fig. 1. Cracks that appeared under maximum load of 160,000 lb. on a 6-ft. span when a shear of 860 lb. per sq. in. was developed.

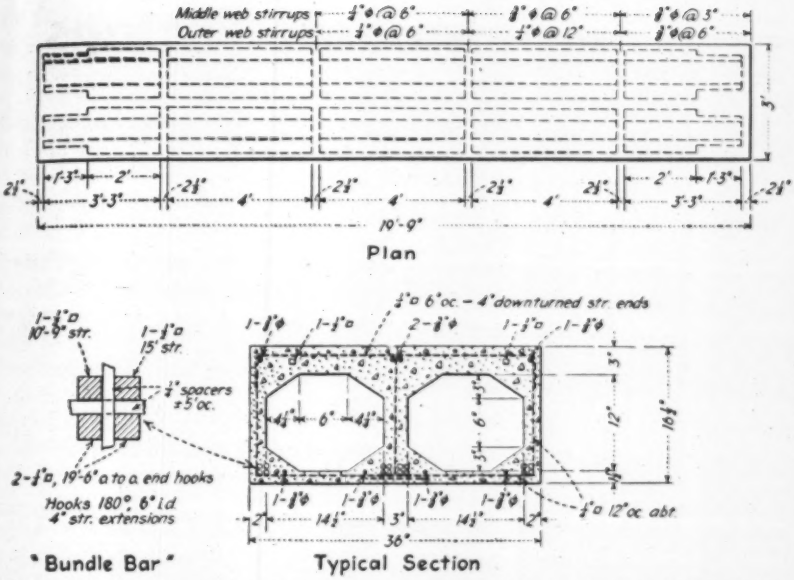

Fig. 2. Details of precast concrete box beam. Note thin but filleted diaphragms; also the "bundle bars" used for main reinforcement. The longitudinal diaphragms are thickened at ends to provide better embedment for hooks of bundle bars.

sides. They closed on removal of the load. The 76,000-lb. load, applied with the two jacks, produced hair cracks only. The 160,000-lb. load produced not only the normal fine tension cracks but a well-defined horizontal crack in both sides at the bottom of the top fillets, due undoubtedly to transverse distortion of a 2-span closed frame type resulting from the heavy loads being applied to the top slabs midway between the webs. A fine longitudinal crack also developed in the top of the beam centered over the middle web. The final 60,000-lb. load produced failure by the steel passing its yield point, and although the jacks were pumped until the beam deflection reached 2 in. no increase in load could be produced.

Punching shear test

Lastly a punching shear test of the 3-in. top slab was made with a small steel plate, 3 in. by 2½ in. This punched through at 32,000 lb., which is a bearing of 4,267 lb. per sq. in. and a punching shear of 970 lb. per sq. in. This was on plain concrete—no steel was in the slab beneath the plate. After the load test had been completed the concrete was knocked off and a portion of one "bundle-bar" was exposed to examination. As in two earlier beams it was found that mortar from the concrete had completely filled the inner spaces between the individual bars of the bundle.

Good margin over design loads

If the tabulated loads are divided by 40,000 lb., the quotients express the equivalent loads in terms of fully loaded 20-ton trucks. Thus failure on the full span came by the application, concentrated at midspan, of one and one-half H-20 trucks; on the short 6-ft. span the beam carried the equivalent of four H-20 trucks. It therefore appears reasonable to conclude that such beams can safely carry the loads for which they were designed.

Personnel

Thanks are due to the Northwest Steel Co. of Seattle, which gave the reinforcement, and to the Washington State Highway Department and to the engineering department of the City of Seattle for the loan of their 40-ton jacks. Lacey V. Murrow is director of highways and Bailey Tremper testing engineer of the highway department. C. L. Wartelle is city engineer of Seattle and B. C. Mason is senior engineer in charge of the city testing laboratory.

RESULTS OF TESTS ON CONCRETE BOX BEAM

Span	Total Load	f_s	f_c	v	u	Max. Def. in.	Recovery in.
19'-4½"	46,800	48,800	2010	280	120	⅞	⅞
12'-0 "	76,000	46,200	1900	430	180	⅝	⅝
6'-0 "	160,000	46,600	1920	880	290	¼	¼
19'-4½"	60,000	61,000	2530	350	150	2	1¼

Fire Resistance Value Of Tile and Block

A STUDY OF CLAY PARTITION TILE to improve the strength and fire resistance of the units and partitions has been in progress for several years at Ohio State University in cooperation with the Structural Clay Tile Association. Extensive fire tests of tile and block partitions included in the study are reported by H. D. Foster in Bulletin 104 of the Engineering Experiment Station, "A Study of the Fire Resistance of Building Materials."

Partitions of tile made from fire clay had much greater resistance than those built of shale or surface clay tile; thus 4-in. unplastered partitions of shale or surface clay tile failed in about 14 min., while a similar partition of fire clay tile resisted 31 min. End-construction walls had greater resistance than side construction walls (cells horizontal).

Protecting the surface of the partitions by plaster increased the fire resistance greatly. A 4-in. partition faced with ¾ in. of gypsum plaster on both sides had its resistance period increased from 30 min. to more than one hour. Furring tile gave similar protection for a short time but was soon loosened from the wall.

Fire resistance periods of 2 hr. and more required an 8-in. tile partition (with three cells in the thickness) if unplastered, but 2-hr. resistance could be obtained with a 4-in. partition if the cells were filled with insulating material and the faces were plastered, or with a 6-in. partition of end construction with insulating filling and no plastering.

Chemically bloated clay blocks gave unusually high resistance, up to three or four times longer than similar partitions of ordinary tile. Plastered on both sides with gypsum, these bloated block walls 4 in. thick had a fire resistance of more than 3 hr.

Walls of 8-in. load-bearing clay tile or cinder or Haydite concrete blocks gave resistance periods approaching 3 hr. unplastered and 4 to 5 hr. plastered. Brick facing further increased the fire resistance. A single test of a 3-in. gypsum block partition showed nearly 3-hr. fire resistance and low temperature rise on the exposed side, but the material calcined and the wall became unstable, collapsing soon after cooling.

A "Swimmin' Hole" with Modern Fittings

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U. S. Soil Conservation Service, Milwaukee, Wis.

***Contents in Brief**—Crab Orchard Lake in southern Illinois is the latest addition to our recreational area developments where treated water and other sanitary control features have been applied to a natural swimming pool. Here are the working details of the purification equipment and the method of distributing treated water in the lake, along with information on beach and bath house layout.*

CRAB ORCHARD LAKE'S new beach and swimming area will combine the natural setting of the "old swimmin' hole" with the sanitation facilities and conveniences of a modern indoor pool. The lake, near Carbondale, Ill., will cover a surface area of 7,000 acres and is part of a land utilization project of the Soil Conservation Service. Recreation is one of the uses to which the land will be put and facilities will be provided for swimming, boating, picnicking, hunting and fishing.

The swimming area at Crab Orchard was planned to conform with the following requests of the Illinois state department of public health:

That equipment be provided for supplying treated water to the swimming area.

That the water area be surrounded by a barrier consisting either of steel sheetpiling or planking, the purpose of which is to prevent wave and lake current action from decreasing the efficiency of the circulation and from washing away the beach.

That washed sand be provided for the beach.

That bathhouse facilities be provided, including flush type toilets and warm water showers, and that a suitable fence be placed around the area so that all persons using the beach must pass through the bathhouse and use these facilities.

Factors affecting site

The area finally chosen for the beach development provides a location for gravity flow of sewage from the bathhouse to a treatment plant which will be entirely outside of the drainage area of the lake. It provides the possibility of using an existing water supply if a deep well which is to be drilled at the site does not provide an adequate supply. The beach site is adjacent to a new park road and has an area that can easily be developed as a large parking lot. Furthermore, the beach should be comparatively free of silt because it is on the side of the lake opposite the major part of the total drainage area.

The site is located in a natural amphitheatre so that provision can be made for spectators outside of the enclosed bathing area. The spectator area will be on the west side of the bathing area so that visitors will face away from the afternoon sun.

The beach development will be about 500 ft. long and will vary in width from 100 ft. on the two ends to 250 ft. at the center. It will contain some 35,000 sq.ft. of water area varying in depth from 0 to 3 ft., and about 41,000 sq.ft. of water area varying in depth from 3 to 6 ft.

A sand beach outside of the water area will vary in width from 50 to

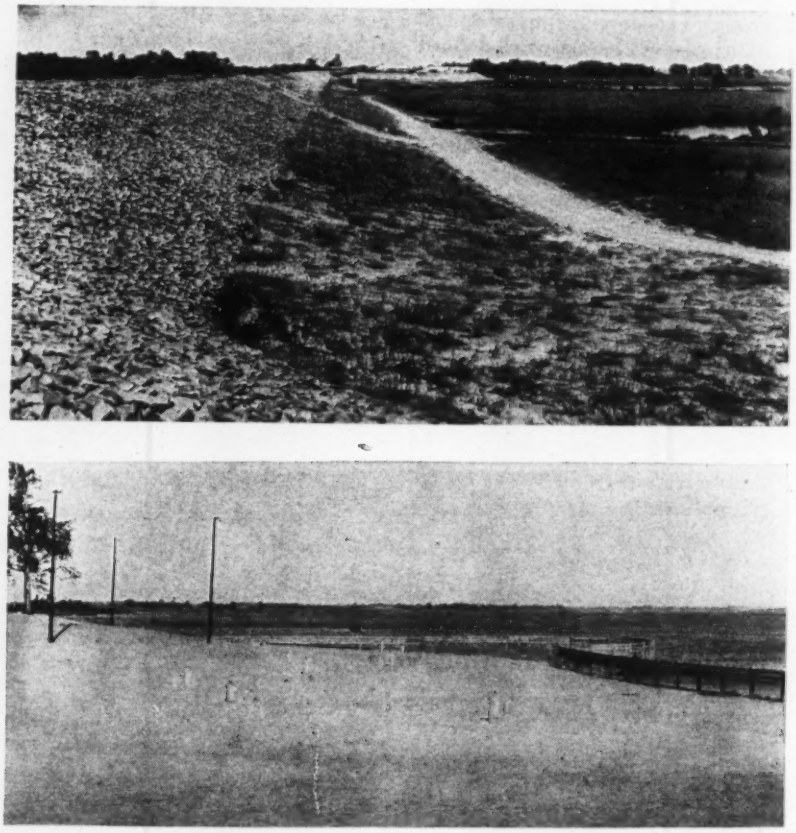


Fig. 1. Before flooding took place behind the dam which forms Crab Orchard Lake. The lower picture shows the completed underwater portion of the beach before it was inundated; the timber breakwater is to reduce wave action and define the safe bathing limits.

125 ft. The bottom of the swimming area will have a uniform slope varying from 2 per cent at the center to 5 per cent on the two ends. Two diving areas having a minimum water depth of 15 ft. will be located outside of the swimming area proper. The bottom of the beach will be surfaced with a 12-in. thickness of sandstone compacted to form a solid base which will prevent mud from working up through the upper layer of sand. The sand layer will cover the sandstone base to a thickness of from 4 to 6 in.

The entire swimming and diving area will be surrounded by timber breakwater constructed of posts spaced 10 ft. apart, each having a top size of 8 by 8 in. These posts will extend 18 in. above the water surface. They will be connected by five timber rails 3 by 10 in. in size bolted to the posts and spaced about 3 in. apart. This bulkhead will serve principally as a protection against excessive wave action.

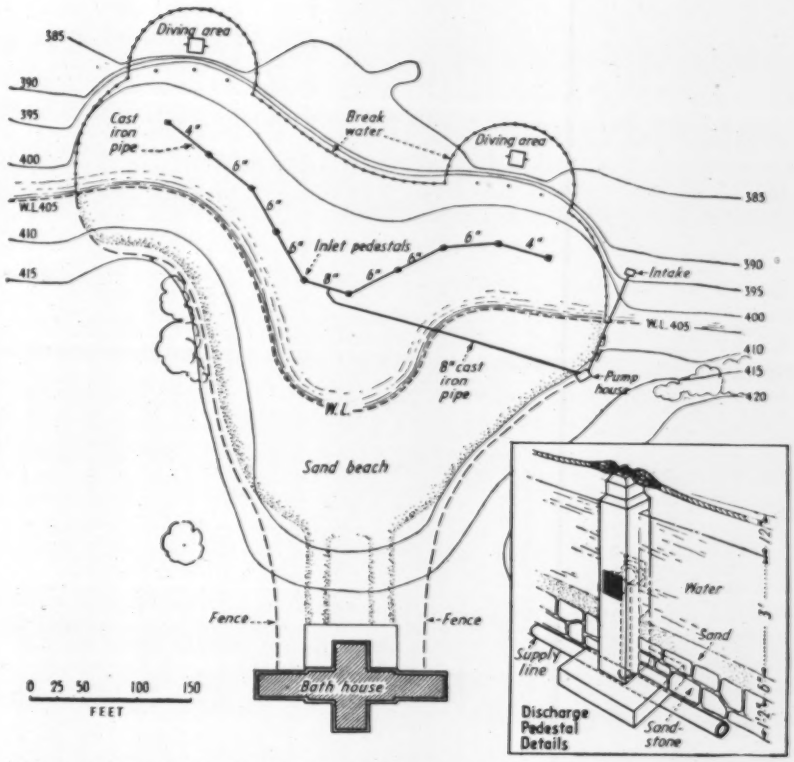


Fig. 2. Beach layout showing the position of discharge pedestals which will distribute the treated water in the swimming area.

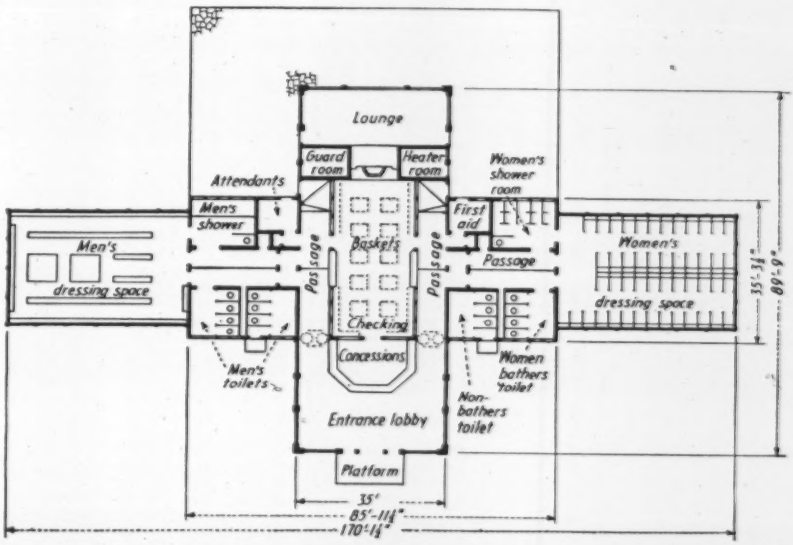


Fig. 3. Bath house facilities are designed to route the bathers properly and thus eliminate crowding as well as to provide adequate accommodations.

Water carefully treated

The principal recommendation of the Illinois state department of health, differing from previous requirements in other states for natural beach developments, called for the installation of equipment for supplying freshly treated water to the swimming area. In the design of artificial swimming pools, disinfection of the water has long been recognized as a safety essential. The practice has generally been considered impractical in natu ral swimming areas, though there have been a few cases in which water has been treated in large lakes.

One case is the Springfield, Ill., public beach on Lake Springfield, which has been operated for several years. It has a water area of 220 by 800 ft. Treated water is applied to the bathing area at the rate of 1,000 gal. per min. which is sufficient to supply, in three days of continuous pumping, an amount equivalent to the water capacity of the entire bathing area.

In the Springfield installation a distribution pipe is laid two feet below the bottom of the beach in a 12x12-in. wooden box containing crushed rock. The water is discharged through small holes in the bottom of the pipe and rises through the rock and sand; the pipe contains about 1,000 holes spaced irregularly. The water is about 3½ ft. deep along the pipe. It has been proved possible to control the water in the bathing area at Lake Springfield so that it has a residual chlorine content of 0.1 to 0.2 ppm.

Plans at Crab Orchard Lake were based to a large extent on the Springfield experience. The principal problem was to provide equipment that would distribute the freshly treated water uniformly. It was found at Lake Springfield that the pipeline holes soon became clogged with sand, requiring the drilling of new holes each spring.

To avoid this, the Crab Orchard plan provides for a line of concrete discharge pedestals spaced 50 ft. apart along the center of the bathing

area, marking the 3-ft. depth. The pedestals rise 12 in. above the water level and serve as supports for a rope safety line. In each pedestal a 3-in. pipe riser connects the main distribution line to two discharge fittings, one facing toward the sand beach, the second facing into the lake. The fittings can be adjusted to change the amount of treated water entering the bathing area from each of the pedestals.

The intake tower for the system, located just outside the bathing area in about 15 ft. of water, is made of concrete with an inside opening 2 ft. square. The tower has a removable concrete top and two of the four sides have screen-covered openings that are readily replaceable. An 8-in. cast iron pipe connects the intake tower to the pump house.

Chlorine-ammonia treatment

The pump house is equipped with a 1,000-gpm centrifugal pump, a 75-lb. capacity chlorinator, an ammoniator, and a separate water supply which can be used for priming the pump or for any other need that might arise. Although chlorine alone if properly applied and controlled will satisfactorily disinfect swimming water, it is planned to use ammonia in addition to chlorine for the following reasons:

(1) The bathing load will fluctuate widely, causing a great variance in the necessary dosages. It is difficult to maintain the residual disinfectant at a constant level with chlorine alone.

(2) The swimming area will be exposed to the direct rays of the sun and to considerable air circulation which causes escape of free chlorine and rapid diminishment of the residual disinfectant.

(3) The bactericidal effect persists longer if ammonia is used in addition to chlorine.

(4) Less chlorine is required, thereby reducing the cost of operation.

(5) The chloramines resulting from the reaction of the chlorine and ammonia in the water are odorless and non-irritating, whereas water treated with chlorine alone in large quantities is irritating to the eyes and nose and has objectionable chlorine fumes when the water is agitated.

It is planned to apply ammonia equal to one-third the weight of chlorine. The alkalinity of the water will be maintained between pH 7.4 and 7.6 by the addition of the proper amount and regulation of soda ash.

The chlorine is to be applied to the 8-in. suction line ahead of the pump and the ammonia is to be applied to the discharge line from the pump to the distribution system. The latter pipe, which is connected to the center of the beach distribution line, decreases in size from 8 in. in the center to 4 in. at the ends. There are to be 10 discharge pedestals with 20 control fittings. As the beach zone has a capacity of about 1½ million gallons of water, it will be possible to supply an equivalent amount of treated water in 25 hr. operation of the pump. Approximately 8 hr. pumping per day will provide treatment equivalent to the maximum capacity of the Lake Springfield system. This will permit more flexible operation of the system and better control in cases of suddenly changing swimming load.

The swimming load capacity of the beach is conservatively estimated to be 3,000 persons, allowing 25 sq.ft. per bather, or 500 gal. per bather. Based on the rate of 20 persons per 1,000 gallons of fresh treated water added, the swimming area would provide for a turnover of 1,200 persons per hour or 12,000 persons during a 10-hr. day.

Bathhouse facilities

The bathhouse, located some 200 ft. from the water's edge, has been designed to provide proper routing of the bathers. There is a central area containing checking facilities which provide control over entrance to the two dressing rooms. The latter are of the roofless type which provide good ventilation and take full advantage of sunshine. A small portion of each dressing room is roofed, however, to provide some shade and protection from rain. The floors of the dressing room are concrete and have a pitch of 4 in. in 14 ft. to a center drain trough covered with a metal grate. Hose connections are conveniently located for use in cleaning all floors, walls, walks, etc. Individual dressing booths are provided in the women's dressing room.

Three types of toilets are provided in separate locations: (1) outside public toilets for spectators; (2) toilets adjacent to the dressing room which are known as "inside dry" and which can be used by patrons while dressing without using floors and fixtures wet from bathers; (3) toilets adjacent to the showers which are known as "inside wet" intended for patrons while in the shower room or swimming area.

The patrons are routed from the dressing room to the shower room where warm water is available. Liquid soap dispensers supplement each shower. From the dressing and shower rooms, the bathers file past the checking room, where clothes can be checked in individual baskets, to the rear doors of the bathhouse, which serve as the only entrances to the beach, as the entire area is enclosed by a fence. The passageway from the checking room to the rear door contains a foot bath through which all persons entering or leaving the swimming area must pass.

The bathhouse also contains rooms for first aid, lifeguards, attendants, and a water heater. In addition, a large glass and screen enclosed lounge room faces the swimming area for use of the patrons for shelter from the sun on hot days or from the elements during sudden storms. Food and drinks will not be permitted in the swimming enclosure so provisions have been made for a concession counter at the front entrance to the bathhouse. Floodlights are provided for lighting the beach and swimming area at night.

Development of the recreational area is being carried out as a project of the Illinois State Work Projects Administration, under the technical supervision of the U. S. Soil Conservation service.

Radio Towers Demolished

Three radio towers in the Chicago region were demolished on Nov. 11, one being blown down in the high wind of that day and two others being pulled down. Curiously enough, the tower blown down was one of three 360-ft. towers of radio station WIND at Gary, Ind. It broke at about mid-height, the upper section falling as if hinged at that point. The towers pulled down were the twin 300-ft. towers of station WGN at Elgin, Ill., built in 1926. They have been superseded by a single 750-ft. tower at Roselle, Ill. The two towers were of triangular section. In taking them down one leg of each was cut through at the base with a torch and the anchor bolts of the other two legs were cut. A motor truck with a cable attached to the front leg pulled the structure down.

From Field and Office

Working problems and time-saving methods for engineers and contractors

Anchor Rod Length Fixed by Field Tests

In the design of the South District water filtration plant at Chicago, now being built in the lake at the foot of 79th St., it was found necessary to anchor the substructure to the underlying bedrock to resist uplift that will occur when various basins are dewatered. Specifications required that the contractor make a series of tests after the rock had been exposed to determine its holding power and the length of anchor rods required.

The tests were made on anchor rods consisting of two 1½-in. square twisted bars grouted into 3½-in. holes drilled in the rock. One series of tests was made on anchors set 6 ft. and another on rods set 8 ft. into the rock. To simulate actual conditions in the structure tests were made on four sets of anchors simultaneously.

The test setup is shown in the accompanying illustration. Two sets of two double I-beam assemblies were placed at right angles to each other, one set of anchor rods extending upward between each pair of beams. Plate collars were welded to the rods to bear against the top flanges of the beams. At one end the beams rested on an I-beam fulcrum while the other end was supported on a hydraulic jack. By applying a predetermined pressure to the jacks, all four sets of anchor rods could be uniformly stressed.

The pull on the rods was carried well beyond specification requirements without any sign of failure in the bond or holding power of the rock. An anchor length of 6 ft. in the rock was determined as ample to meet all requirements for the structure.

Michael Pontarelli & Sons, contractor on the substructure, carried out the tests under the direction of the commissioner of public works and the city engineer of Chicago.

Set-up for anchor rod tests on Chicago water filtration plant.

Drawing Accurate Irregular Curves

While working on the contract drawings for the Henry Avenue Bridge over Wissahickon Creek in Philadelphia, it was necessary to draw a large number of small ellipses, each identical in size and shape. They were all in a row, and any deviations from uniformity would have been very noticeable. In order to get a good-looking job without taking too much time, a large ellipse was drawn accurately and photographed on cut film to the size needed. Then the inside of the developed image, on the negative, was roughed out with a punch and the edges smoothed with emery cloth to form a templet of the exact size and shape needed.

The writer has since found this method to be convenient whenever, for reasons of appearance or accuracy, small curves must be drawn precisely. It is especially useful for drawings on stencils.—CHESLEY J. POSEY, *Assistant Professor of Hydraulics and Structural Engineering, State University of Iowa.*

Simple Method of Bracing For Earthquake Shock

Diagonal, 2 x 4-in. bracing between the studding has long been a means of stiffening better-built structures of the wood-frame class. In earthquake regions, the diagonals are now being made more secure and a high degree of panel rigidity is assured by nailing "kick blocks" to the stud to take the thrust from these diagonals at each obtuse angle. At these joints, brace ends are cut to a horizontal plane thus providing a square shoulder for tight fit.

Semaphores Control Traffic Through One-Way Tunnel

Oneonta Tunnel on the Columbia River highway in Oregon is no longer considered safe for two-way traffic with modern automobile speeds and large truck sizes. Hence, to expedite traffic at this point an automatic semaphore control system has been put in which shows alternately red and green signals at opposite portals with resultant increase in speed and safety of traffic movement.

Notes on Sewage Disposal

A monthly summary of current developments conducted by Willem Rudolfs

POLLUTION BY INSECTS? —From time to time pollution of wells is found without apparent cause. Recently, samples of water analyzed showed intensive contamination with the only apparent source of pollution a number of tent caterpillars which had accidentally fallen into the well. It is well known that human fecal bacteria may inhabit flies and may survive passage through the intestinal canal of the insect; however, not much information is available concerning the nature and kinds of bacteria which comprise the flora of insects. An interesting review on the microbiology of insects by Steinhaus (*Bacteriological Reviews, vol. 4, p. 17, Mar. 1940*) with special reference to the biological relationships between bacteria and insects does not throw much light on the question raised.

SLUDGE DRYING—At many plants utilizing digestion a considerable portion of the byproduct gas is wasted. Where power production is practiced, provision for recovery of waste heat from the engines makes complete utilization of heat possible. An example of utilization for drying of sludge was described by Phillips in a paper presented before the 1940 meeting of the New Jersey Sewage Works Association. A piping system was devised whereby the excess heat from a heat exchanger was conducted through ¾-in. galvanized iron pipe installed in four covered drying beds with open sides. The heating coils were laid just below the sand surface and through them all excess hot water not needed for temperature control of the digestors was passed. The pounds of dry solids removed per year from 10,000 sq.ft. of covered sand beds were as follows:

No heat (1936–38)	325,423
Heated (1939)	424,490

The heated beds were out of service during one month for cleaning and repairs, so that the total removal for the year could be estimated as 464,500 pounds dry solids. The additional drying gained is said to more than pay for the investment. More important was that sludge could be moved when drying space was most needed. The cost of the sludge heating equipment on the drying beds amounted to roughly 25c. per sq.ft. of drying area, or less than 10 per cent of the total cost for covering the beds. On the basis of one year's experience it was found that 43 per cent more dry solids could be removed.

FILTER FLIES—Competition for a limited food supply by various species of insects in trickling filters leads to a reduction in the numbers of flies breeding in the beds. It is well known that the numbers of flies increase rapidly with higher temperatures, resulting in the largest numbers being present in the late summer or early fall. Studies by Golightly (*Annals of Applied Biology, vol. 27, 406, 1940*) show that temperature also affects size—the higher the temperature the smaller the flies. The size of the flies falls steadily from winter to midsummer and then rises again. Another factor affecting the size of the insect is crowding—the greater the numbers the smaller the flies.

That numbers of flies can be extremely high is evidenced from a conversation with William Hansell, engineer of sewers and disposal at Atlanta, Ga. He stated that at Atlanta the trickling filter effluent is screened to retain the fly larvae. The large number of larvae was so impressive that the superintendent of the Intrenchment Creek and South River plants made some count and weight estimates on September 24, 1940, when 117 wheelbarrows full were removed. His calculations showed that on this day some 2,039,310,000 larvae were caught by the screens from a filter bed of 2.1 acres. This means that there would be 6,800 flies for each person in Atlanta or more than 15 for each person in the United States.

CHEMICAL TREATMENT—A method of sewage treatment described as simple, automatic, rapid, efficient, requiring a minimum of supervision and producing a good effluent with sludge that dewaters easily, would seem the answer to extensive search. This process (*La Technique Sanitaire et Municipale, April, 1940*) operated at Athus, Belgium, is chemical-mechanic and abiotic in the sense that during the process of purification microscopic life is impossible. The units are principally dosing, grinding and mixing devices. The chemicals are mainly lime, alum and silica. The lime must be applied as a slurry. All chemicals are fed in proportion to the requirements of the particular sewage or waste. When the optimum quantities have been determined the process becomes automatic, producing clarification of 85 per cent in 3 minutes and 98 per cent after two hours' settling. The sludge concentrates about 1,250 times and is readily dewaterable to 60 per cent moisture content on vacuum filter or drying bed. Since all suspended material has been removed and sterilized by the treatment, the effluent is claimed to be non-putrescible. Visitors have been impressed by the efficiency and simplicity, making this process ideal for certain industries and small communities. The claims are of interest in view of results obtained with alumina-silica trials in this country.

NEUTRALIZED chromium plating wastes in concentrations of 250 ppm kill perch in 3½ hours; with 100 ppm they were alive after 18 hours. If the chromate concentration is reduced to a point where it does not interfere with biological sewage treatment, fish will not be injured.

MOSQUITO breeding activity at and around sewage treatment works is principally confined to shaded and stagnant collections of water. Removal of shade and drainage of stagnant places help greatly in control.

EXPERIMENTS conducted at Leeds, England, have reaffirmed that the cause of ordinary unloading of trickling filters is mainly the result of worms and insect larvæ working over the biological slime loosened from the stones by anærobic bacterial action. The leathery growth is changed to a spongy mass and washed out.

Book Notes and Reviews

The month's addition to the engineer's reading and reference list

Writing Guides

TECHNICAL EXPOSITION—By Leslie M. Oliver. 193 pp. Published by McGraw-Hill Book Co., New York and London. Price $1.50.

HANDBOOK OF ENGLISH IN ENGINEERING USAGE—Second Edition. By A. C. Howell. 433 pp. Published by John Wiley & Sons, New York; Chapman & Hall, London. Price $2.50.

Written primarily for college students, Oliver's "Technical Exposition" will be found helpful to anyone who is engaged in the preparation of technical reports or the writing of papers for engineering societies. Of special value are the sections on organization of technical papers and effective use of English. A considerable section of the book is devoted to the preparation of business letters.

Howell's book, now in its second edition, is more comprehensive in its scope and is designed for use by the practicing engineer rather than the student. It is supposed to be a handbook to go along with Trautwine and Merriman on the engineer's desk where it can be picked up quickly to answer a specific question.

Surveying Texts

SURVEYING—Third Edition. By Raymond E. Davis and Francis S. Foote. 1,032 pp. Published by McGraw-Hill Book Co., New York and London. Price $5.

ENGINEERING SURVEYS—Revised Edition. By Harry Rubey, G. E. Lommel and M. S. Todd. 140 pp. Published by The Macmillan Co., New York. Price $3.50.

BOUNDARY PROBLEMS AND DEVELOPMENT PROJECTS—By D. G. W. Ricketts. 131 pp., 140 plates. Published by Pelican Publishing Co., New Orleans. Price $4.

"Surveying" has been largely rewritten to incorporate changes in practice since the second edition appeared in 1934 and to improve the method of presentation. A notable addition is a chapter on photogrammetric surveying by Capt. B. B. Talley of the U. S. Engineers.

Numerous minor changes have been made in "Engineering Surveys" to bring it up to date. The major addition is an appendix with sample forms for field notes and computations.

"Boundary Problems" is written not so much for surveyors as it is to provide landowners, real estate men and bankers with a better knowledge of the difficulties in land descriptions and to tell them what to look for in surveys and descriptions. Nevertheless, the landsurveyor will find much of value to him in the book. The practicing civil engineer who is less conversant with land-surveying problems will find it helpful when he is faced with such problems.

The Am. Soc. C. E. Schedule of fees for engineering service is included for the benefit of the employers of engineers and landsurveyors.

Sewage Disposal Practice

SEWAGE TREATMENT WORKS—By C. E. Keefer. 673 pp. Published by McGraw-Hill Book Co., New York and London. Price $6.

SEWERAGE AND SEWAGE TREATMENT—By Harold E. Babbitt. Fifth Edition. 648 pp. Published by John Wiley & Sons, Inc., New York; Chapman & Hall, Ltd., London. Price $5.

At last a book on sewage treatment has been written primarily for operating men. C. E. Keefer has done a good job, with a sympathetic understanding of the problems of the operator. No one could be better qualified in this regard, because the author has actually operated one of the major sewage disposal plants in the country and he has long been identified with practical research leading to new developments.

This book provides an exceptionally useful compilation of information on the administration and operation of treatment works. Furthermore, the merit of its presentation is enhanced by including simple but complete explanations of fundamental theories in chemistry, hydraulics, biology and allied sciences, all of which are essential to an intelligent understanding of process applications and their performance. Practical, complete and up-to-date, this book may be considered as both a text and a manual which tells the "why and how" of sewage disposal practice.

The fifth edition of "Sewerage and Sewage Treatment" by Prof. Harold Babbitt, attests to the popularity and acceptance of this text in the sanitary field. The basis of this book when it was first published in 1922 was a compilation of classroom and lecture notes used by the author in presenting a comprehensive course on sewage disposal. With changes in practice have come changes in the book, and in the present edition the author has revised the contents to include new developments and current thinking in the art.

Airports Described

AIRPORTS—By John Walter Wood. 364 pp. Published by Coward-McCann, Inc., New York. Price $12.50.

Considerable information of value to airport designers is scattered through this book. The subject is approached chiefly by means of descriptions of actual airports, all the major airports of the world being described and illustrated by many pictures and plan drawings. These portrayals give the layout of the fields, dimensions and character of the major buildings, runway lengths and type of construction, drainage system, details of the lighting and control installations, costs, traffic and income. No effort has been made to assemble this information in easily usable form. Information as to landing field construction and drainage is very limited.

Municipal Public Relations

MUNICIPAL PUBLIC RELATIONS—Elton D. Woolpert. 50 pp. Published by the International City Managers Association, 1313 E. 60th St., Chicago. Price, $1.00.

The objectives of this book are to define the nature and scope of public relations, to suggest in broad outline a program for improving relations with the public, and to illustrate these suggestions with specific devices or practices which have been found useful in actual practice, says Elton Woolpert, the author. With these objectives and a sympathetic under-

standing of municipal management problems, Mr. Woolpert has prepared a worthwhile treatise for administrators and public works officials. In fact, this is the only complete text available on the highly specialized business of public relations and municipal government. Of particular interest are the chapters on handling inquiries and complaints, personnel practices, municipal reporting and publicity, and physical appearances and public relations.

Miscellaneous Notes on Booklets and Reprints

PROGRESS REPORTS on the joint investigation of fissures in railroad rails and the joint investigation of continuous welded rail, presented at the annual meeting of the American Railway Engineering Association in March, have been reprinted by the Engineering Experiment Station, University of Illinois, Urbana, as Leaflets Series Nos. 16 and 17.

A SHORTCUT to the extraction of square roots to five significant figures, requiring only one addition and one division after using a table of divisors that goes on a single, letter-sized sheet, has been developed recently by the Marchant Calculating Machine Company, 1471 Powell St., Oakland, Calif., from whom the table may be obtained for a 3-c. stamp to cover postage. The table, which is copyrighted, is similar to a cube-root compilation announced by the same company last spring.

DATA ON SOIL MECHANICS included in 12 papers which have appeared in the *Journal* of the Boston Society of Civil Engineers and one paper from the *Journal* of the New England Water Works Association are to be published soon by the Boston Society of Civil Engineers under the title, "Contributions to Soil Mechanics." (Price, $1.75.)

AN HISTORICAL RECORD of suspension bridges compiled by Prof. A. A. Jakkula of the Agricultural & Mechanical College of Texas, is now being prepared for publication by the Texas Engineering Experiment Station under the title of, "The History of Suspension Bridge in Bibliographical Form." The typewritten manuscript totals nearly 700 pages and contains over 4,000 references to articles on the various aspects of suspension bridges. As the cost of reproduction will depend in considerable part on the number of copies that will be required, those interested in obtaining copies are requested to communicate with Gibb Gilchrist, Director of the College Station, Texas.

BENTONITE as a material for use in checking seepage through small dams is the subject of a report prepared by Ben F. Powell, construction engineer, U. S. Forest Service, Denver, Colo. Copies may be obtained from the Forest Service or from the Wyodak Chemical Co., Cleveland.

PLUMBING AND PUBLIC HEALTH is the subject of Bulletin No. 256, U. S. Public Health Service. It describes special investigations made in a federal building survey and discusses the evaluation of plumbing inspection and correction of hazards. For sale by the Superintendent of Documents, Washington, D. C., price 30c.

New Engineering Books

TECHNICAL EXPOSITION—By Leslie M. Oliver. 193 pp. Published by McGraw-Hill Book Co., New York and London. Price $1.50. *Reviewed on p. 77.*

COFFERDAMS—By Lazarus White and Edmund Astley Prentis. 273 pp. Published by Columbia University Press, New York City. Price $7.50.

WAVERLY—A Study in Neighborhood Conservation—97 pp. Published under the direction of the Federal Home Loan Bank Board, Washington, D. C.

AIRPORTS—By John Walter Wood. 364 pp. Published by Coward-McCann, Inc., New York City. Price $12.50. *Reviewed on p. 77.*

HOUSING FOR DEFENSE—A Review of the Role of Housing in Relation to America's Defense. 208 pp. May be obtained from The Twentieth Century Fund, 330 W. 42nd St., New York. Price $1.50.

1940 SUPPLEMENT TO A.S.T.M. STANDARDS INCLUDING TENTATIVE STANDARDS—Part I, Metals. 479 pp. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa.

NATIONAL CONFERENCE ON PLANNING 1940—194 pp. Published by the American Society of Planning Officials, 1313 East 60th St., Chicago. Price $2.

SOIL PHYSICS—By L. D. Baver. 370 pp. Published by John Wiley & Sons, New York; Chapman & Hall, London. $4.

STRESS ANALYSIS AND DESIGN OF ELEMENTARY STRUCTURES—By James H. Cissel. 335 pp. Published by John Wiley & Sons, New York; Chapman & Hall, London. Price $4.

ARC WELDING INSTRUCTION COURSE—Published by Air Reduction Sales Co., New York. Price: Exercises, $1; Lectures, $1.

INSTRUCTIONS IN OXYACETYLENE WELDING AND CUTTING PROCESSES—Published by Air Reduction Sales Co., New York. Price, Work Sheets, 50c.; Lectures, $1.

Reports and Pamphlets

ENGINEERING DEFENSE TRAINING—Published by the American Library Association, 520 N. Michigan Ave., Chicago. Price 25c.

THE PORT OF PORTLAND, OREGON—For sale by the Supt. of Documents, Washington, D. C. Price 75c.

MANCHESTER, England. Annual Report of the Rivers Department, 1940. Price 2s 6d.

BUILDING MATERIAL REPORTS recently published by the National Bureau of Standards as additions to the bureau's report on "Building Materials and Structures" include the following: "Strength of Soft-Soldered Joints in Copper Tubing"; "Effect of Soot on the Rating of an Oil-Fired Heating Boiler"; "Effect of Ceiling Insulation upon Summer Comfort". Obtainable from Superintendent of Documents, Washington, D. C. Price 10c.

ECCENTRIC APPLICATION OF LOADS TO GROUPS OF RIVETS—By W. W. Pearse. 51 pp. Published by The Ryerson Press, Toronto. Price $2.25 (Canadian).

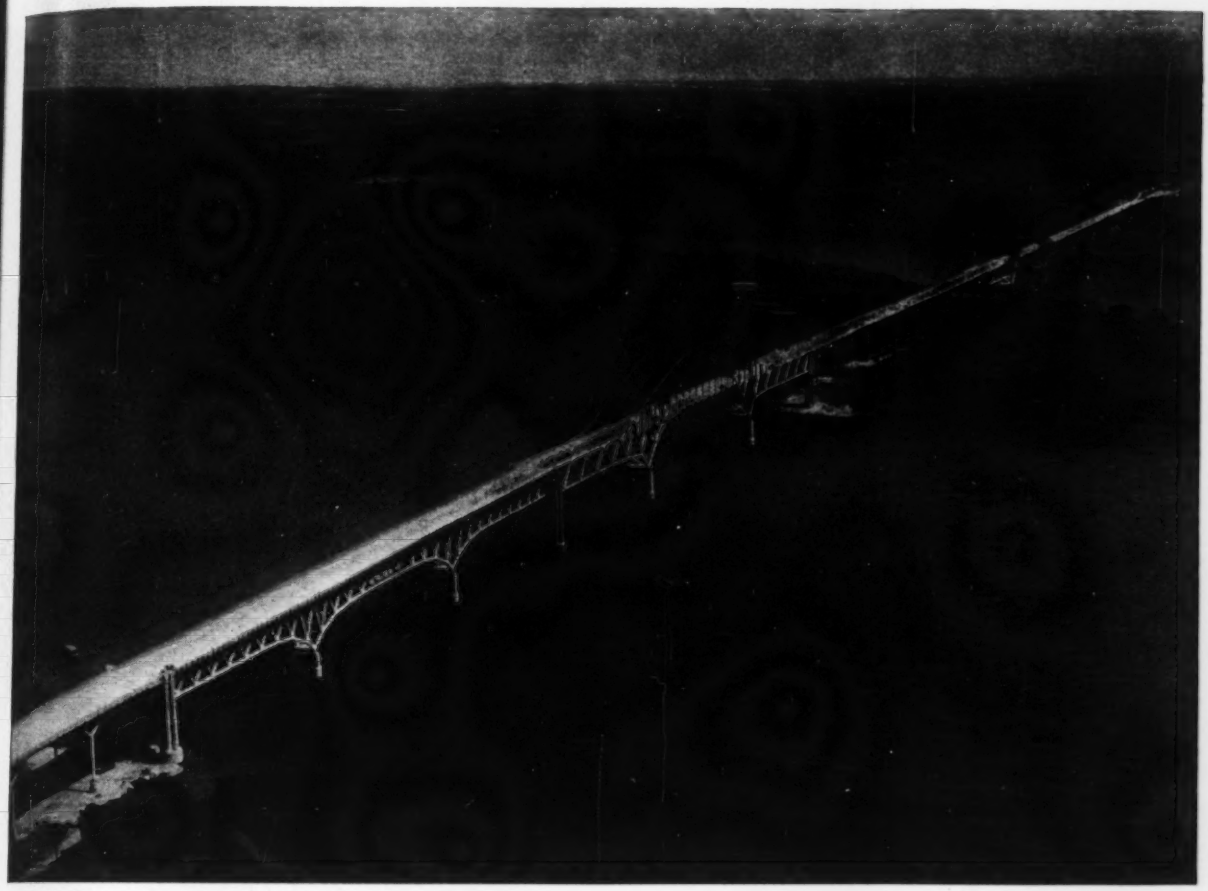
A RATIONAL METHOD OF ANALYZING WATER RATE STRUCTURES—Published by the Texas Engineering Experiment Station, College Station, Texas. Series No. 50.

RURAL WATER SUPPLY AND SEWERAGE—Published by the Texas Engineering Experiment Station, College Station, Texas. Series No. 51.

MILWAUKEE, WIS.—Annual Report to the Citizens, 1939, by the Common Council.

ST. LOUIS, MO.—Annual Report of the Water Commissioner. 1940.

(Continued on p. 85)



7,600 ft. Havre de Grace Bridge embodies unusual panel design

The new Susquehanna River Bridge at Havre de Grace, Maryland, is unique in design. J. E. Greiner Co. the consulting engineers employed over each pier pinned Wichert rhomboid panels instead of ordinary triangular panels. This principle was applied to all of the 49 truss, girder and arch spans of the bridge.

The carrying out of contracts involving unusual or unique designs in monumental bridge structures like this calls for broad range experience, a high degree of engineering skill and ample equipment on the part of the steel constructor. Bethlehem's fabrication and erection division has all of these qualifications; evidence is found in the impressive list of important bridges which it has erected during the past forty years.

BETHLEHEM STEEL COMPANY

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

KANOPOLIS DAM AND SPILLWAY KANSAS

OWNER: U. S. Engineer Office, Kansas City, Mo.

PROJECT: Construction of the earth dam and excavation for the spillway of the Kanopolis Dam, Smoky Hill River, Ellsworth County, Kansas. Length of embankment, 15,400 ft.; maximum width at base, 1,600 ft.; top width, 25 ft.

CONDITIONS: Contractor to furnish all material and complete work by June 30, 1943. Rail and highway transportation facilities available. Wage rates specified are: skilled labor, $1.25 to $1.35 per hr.; semi-skilled, 75c to $1.00; common, 55c.

BIDS: Six bids were opened November 18, 1940, ranging from the contract low of $4,889,978 to $5,915,195.

LIST OF BIDDERS:

1. Marsch-Peterson-Walker-Condon, Chicago, Ill. — $4,889,978
2. Martin Wunderlich Co., Jefferson City, Mo. — 5,466,615
3. Missouri Valley Bridge and Iron Co., Leavenworth, Kan., and Winston Bros. Co., Minneapolis, Minn. — 5,606,217
4. S. J. Groves & Son Co., Lundin Bros., and Clark, Kearney & Stark, Minneapolis, Minn. — 5,619,929
5. Morrison-Knudsen Co., Inc., Boise, Idaho, and Utah Constr. Co., San Francisco, Calif. — 5,684,736
6. W. E. Callahan Constr. Co., Dallas, Tex. — 5,915,195

Item	Quan.	Unit Prices (1)	(2)	(3)
1. River diversion and cofferdam pumping	L.S.	$15,000.00	$17,000.00	$63,620.00
2. Remove existing structures	L.S.	2,500.00	5,000.00	9,192.00
3. Clearing, embank. area	L.S.	62,850.00	90,000.00	19,420.00
4. Grubbing, embank. area	L.S.	62,850.00	90,000.00	34,820.00
5. Foundation preparation	59,700 sq.	10	05	20
6. Excavation, stripping	520,500 c. y.	14	20	15
7. Excav., found., rt. abutment	258,500 c. y.	195	25	30
8. Excav., found., left abutment	116,000 c. y.	195	20	34
9. Excav., outlet approach channel	20,000 c. y.	22	35	33
10. Excav., borrow arer A	1,385,000 c. y.	15	18	17
11. Excav., borrow area B	2,802,000 c. y.	15	18	18
12. Excav., borrow area C	3,570,000 c. y.	16	24	20
13. Excav., borrow area D	1,615,000 c. y.	16	20	20
14. Excavation, borrow area E	2,912,000 c. y.	16	21	20
15. Excavation, borrow area F	469,000 c. y.	15	25	18
16. Excavation, borrow area G	1,090,000 c. y.	15	18	18
17. Excavation, borrow area H	596,000 c. y.	15	16	16
18. Excavation, borrow area J	226,000 c. y.	125	16	15
19. Excavation, borrow area S	2,226,000 c. y.	23	28	30
20. Excavation, borrow (wasted at above borrow areas except S)	658,000 c. y.	13	16	13
21. Excavation, borrow area S wasted at waste area 1	474,000 c. y.	25	23	23
22. Rolled fill, pervious	2,202,100 c. y.	06	05	07
23. Rolled fill, random	5,028,200 c. y.	06	05	06
24. Rolled fill, impervious	4,555,700 c. y.	06	05	06
25. Upstream blanket	1,988,000 c. y.	02	02	02
26. Downstream berm	894,000 c. y.	02	02	02
27. Rolling, for add'l. 2 trips	1,600,000 sq.	01	01	01
28. Riprap	130,000 c. y.	4.00	3.00	3.80
29. Spalls	43,400 c. y.	3.75	2.00	3.65
30. Coarse sand and gravel	65,600 c. y.	75	25	70
31. Gutters	23,000 l. f.	1.25	1.00	1.25
32. Catch basins, complete	16 ea.	150.00	100.00	220.00
33. Pipe drains, 24-in	1,000 l. f.	3.00	3.00	7.50
34. Pipe drains, 30-in	4,150 l. f.	4.00	4.50	9.50
35. Outfall paving	34 sq.	50.00	20.00	40.00
36. Grout for surface drains	720 c. f.	1.00	1.50	70
37. Top soil	95,000 c. y.	10	20	30
38. Seeding	140 ac.	100.00	50.00	100.00
39. Piezometer and settlement gages	L.S.	10,000.00	5,000.00	9,400.00

IMPROVING HIGHWAY, KANSAS

OWNER: State Highway Commission of Kansas, R. B. Wills, State Highway Engineer, Topeka.

PROJECT: Improving 3.946 miles of Highway 15-E, Washington County, Kan. Involves all grading, earthwork, culverts and drainage structures in connection with project.

CONDITIONS: Contractor to furnish all materials and complete work in 160 working days. Rail and highway transportation facilities available. Minimum wage rates stipulated are: skilled labor, 65c. per hr.; semi-skilled, 50c.; and common, 40c. per hr.

BIDS: Eight bids were opened October 5, 1940, ranging from the contract low of $86,922 to $107,937.

LIST OF BIDDERS:

1. T. F. Marbut, Emporia, Kan. (contract) — $86,922
2. C. E. Gray, Emporia, Kan. — 92,269
3. Geo. Bennett Constr. Co., Kansas City, Kan. — 92,393
4. Mike Haase, Kansas City, Mo. — 93,835
5. Gerard Knutson, Independence, Kan. — 95,219
6. Western Contracting Co., Sioux City, Iowa — 96,120
7. D. G. Hansen, Logan, Kan. — 105,563
8. A. G. Sherwood Constr. Co., Independence, Kan. — 107,937

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Large trees	653 ea.	$3.00	$3.00	$3.50
2. Grubbing hedge	249 l. f.	.10	.10	10
3. Remove stone fence	475 l. f.	.10	.20	40
4. Common excavation	301,000 c. y.	.15	.155	145
5. Rock excavation	27,200 c. y.	.30	.45	40
6. Unclassified culvert excavation	754 c. y.	1.50	1.00	2.00
7. Rolling and tamping	261,657 c. y.	.02	02	025
8. Water hauled	6,280 M gal.	.01	10	001
9. Water pumped	6,280 M gal.	1.00	50	1.00
10. Water system	L.S.	5,000.00	5,000.00	1,000.00
11. Class A concrete	1,081.6 c. y.	14.00	14.00	15.50
12. Reinforcing steel	153,130 lb.	.042	.04	045
13. 24-in. entrance pipe	264 l. f.	2.00	2.15	2.30
14. 24-in. side road pipe	108 l. f.	2.20	2.40	2.60
15. Steel plate guard fence	2,375 l. f.	.90	.85	95
16. Wood guide posts	9 ea.	2.00	2.00	2.00
17. Stone wash checks	1,097 l. f.	.60	.50	.45

CANTON DAM, OKLAHOMA

OWNER: U. S. Engineer Office, Tulsa, Okla.

PROJECT: Construction of main embankment section and excavation for main spillway of Canton Dam on the North Canadian River, Canton, Okla. Dam is of earth fill type for flood control, and is 3,700-ft. long. Maximum height 65 ft.

CONDITIONS: Contractor to furnish all materials and complete work in 300 calendar days. Rail and highway transportation facilities available. Shifting sands in the valley and flash floods in river are liable to increase present cost estimates. Wage rates specified are: skilled labor, $1.00 per hr.; semi-skilled, 60c.; and common, 40c. per hr.

BIDS: Eleven bids were opened October 17, 1940, ranging from the contract low of $1,438,652 to $1,812,430.

LIST OF BIDDERS:

1. T. L. James & Co., and Guilliams Bros., Ruston, La. — $1,438,652
2. George W. Condon Co., Omaha, Nebr. — 1,513,666
3. Mittry Bros. Constr. Co., Los Angeles, Calif. — 1,647,010
4. Ralph Myers Constr. Co., Salem, Ind. — 1,667,630
5. S. J. Groves & Sons Co., and Lundin Bros., Tionesta, Pa. — 1,676,213
6. Martin Wunderlich Co., Jefferson City, Mo. — 1,711,504
7. W. E. Callahan Constr. Co., Dallas, Tex. — 1,713,975
8. Morrison-Knudsen Co., Inc., Los Angeles, Calif. — 1,716,342
9. R. W. Briggs & Co., Pharr, Tex. — 1,790,518
10. Marsch-Peterson-Walker, Chicago, Ill. — 1,793,357
11. Western Contracting Corp., Sioux City, Iowa — 1,812,430

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Excavation; stripping	150,000 c. y.	$0.20	$0.253	$0.22
2. Excavation; trench	45,000 c. y.	.18	.253	30
3. Excavation; unclassified	3,665,000 c. y.	.24	.253	245
4. Excavation; borrow	140,000 c. y.	.20	.253	22
5. Excavation; roadway	15,000 c. y.	.30	.253	22
6. Impervious fill	3,525,000 c. y.	.05	.059	08
7. Pervious fill	75,000 c. y.	.10	.059	06
8. Fill in Dikes 2, 3 and 4	1,500 c. y.	.40	.059	30
9. Roadway fill	62,500 c. y.	.06	.059	05
10. Rolling; each add'l. 2 passes	150,000 sq.	.02	.025	02
11. Gravel on dam	63,000 c. y.	2.50	2.00	3.50
12. Gravel on roadway	23,300 s. y.	.60	.40	75
13. Sand in drainage trench	45,000 c. y.	2.25	2.10	2.00
14. Riprap; temp. embank. protect.	3,430 c. y.	2.50	4.50	3.50
15. 12-in. corr. metal pipe	236 l. f.	1.50	1.50	2.00
16. 18-in. corr. metal pipe	530 l. f.	2.50	2.00	3.00
17. 24-in. corr. metal pipe	92 l. f.	4.00	3.00	4.00
18. Field office, car shed, etc	L.S.	12,000.00	22,500.00	28,000.00
19. Sewage disposal system	L.S.	2,000.00	8,500.00	5,000.00